Materials in Design Engineering

SELECTION & USE OF METALS, NONMETALLICS, FORMS, FINISHES

Adhesive Bonding

MANUAL NO. 162

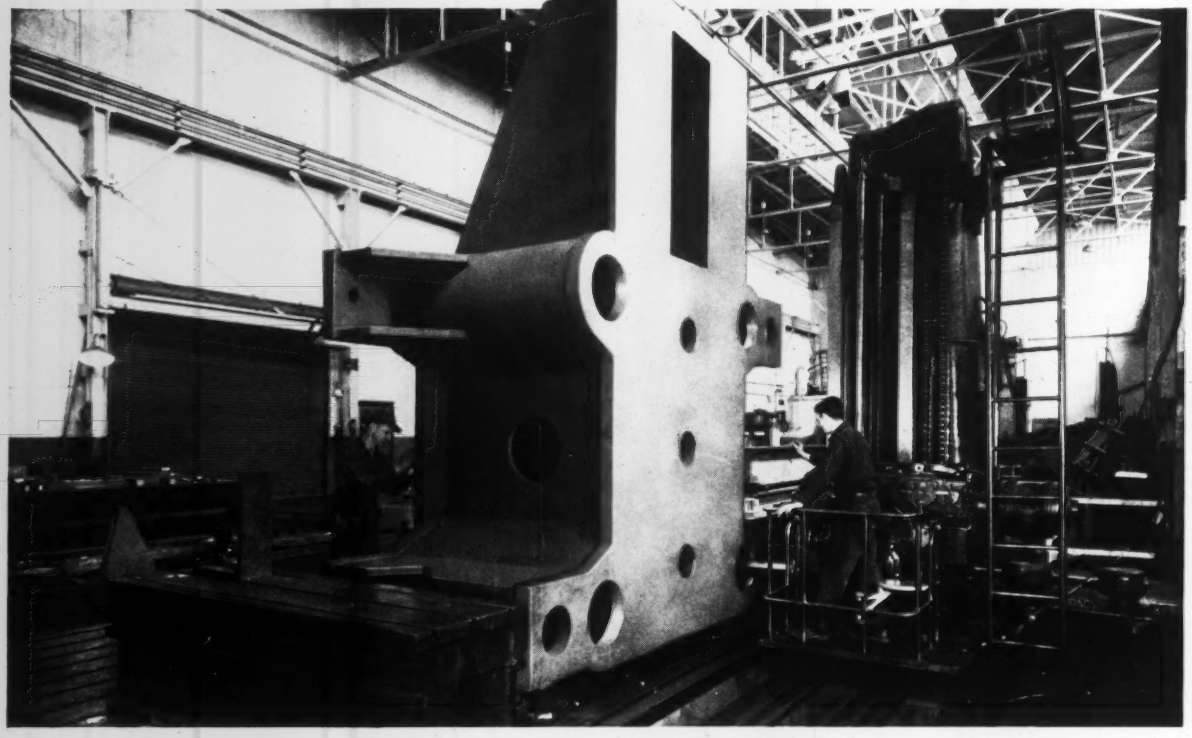
ALSO: IMPREGNANTS FOR CASTINGS

COLD FINISHED STEEL CUTS COSTS

COMPLETE CONTENTS—PAGE 1

TEMBER, 1966

STEEL-WELD FABRICATION . . .



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Materials
in Design Engineering. *formerly Materials & Methods*

Selection & use of metals, nonmetallics, forms, finishes

SEPTEMBER 1959
VOL. 50, NO. 3

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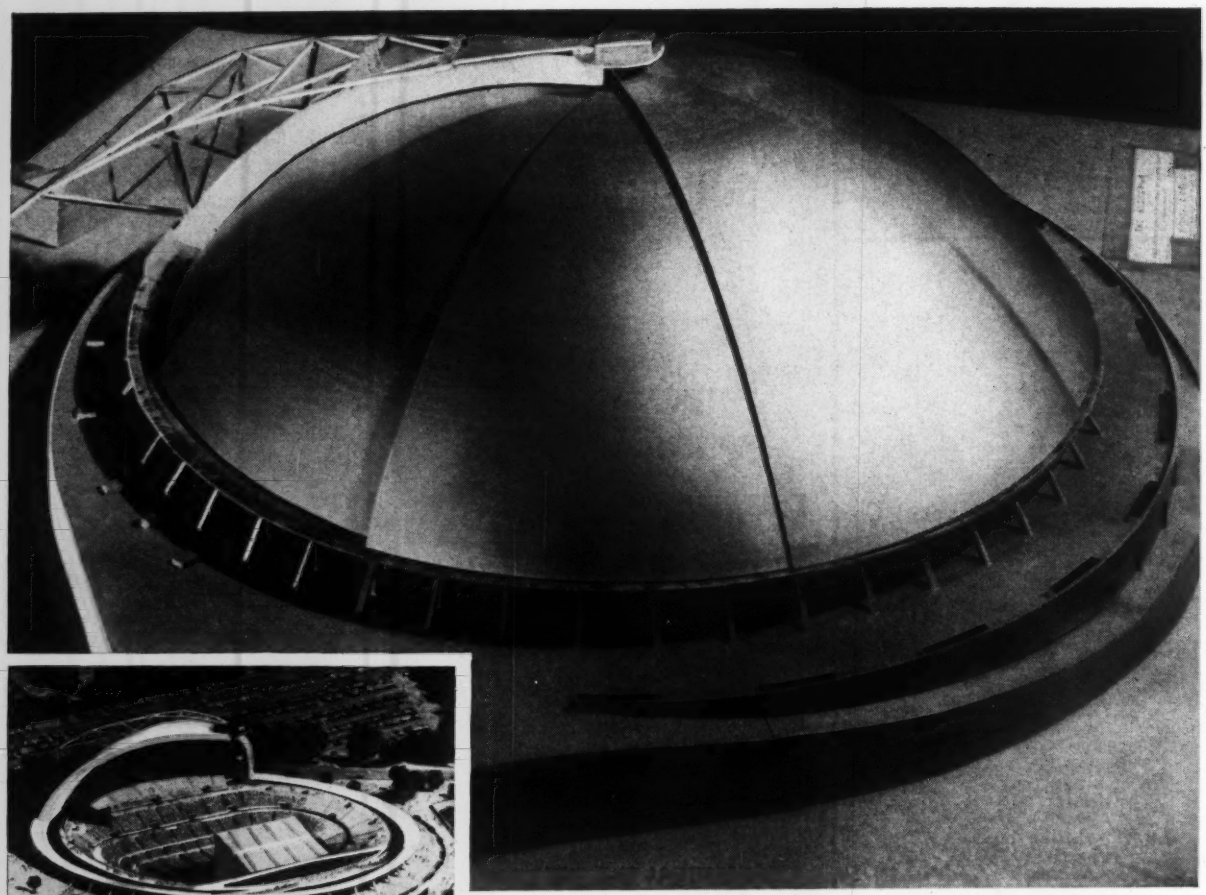
COVER BY HARRY & MARION ZELENKO



All-weather auditorium in Pittsburgh will be covered by a 415-foot diameter Nickel-containing stainless steel dome. Largest of its kind in the world, the dome will protect an audience of more than 13,000.

"Push-button umbrella roof" of stainless steel gives Pittsburgh a new all-weather auditorium

Watching a play or listening to music under the stars heightens the enjoyment. That is, until a passing shower comes along to wash out the fun. But now comes a new idea in auditoriums. In this one, an umbrella roof of Nickel-containing stainless steel will close at the first drops of rain—and on with the show.

It's a simple concept, but a daring one. Eight huge sections nest together when the dome is open. Push a button, and six of these sections glide quietly together around an outside track.

They looked into all sorts of sheathing materials in designing the dome before choosing stainless – a Nickel-containing stainless steel.

For stainless with Nickel in it is one of the most weatherproof metals there is. It is corrosion-resisting all the way through – in salt air as well as industrial atmospheres. What's more, it's virtually self-cleaning – rainfall alone keeps this metal clean.

No wonder you see Nickel-containing stainless wherever strength, long life and handsome appearance are called for! Not only in buildings – inside and out – but everywhere you look.

Suggest something to you? Can stainless help you solve a problem involving corrosion, stress, appearance, temperature extremes? The way to find out is to write us. We'll see if Nickel-containing stainless steel – or some other nickel alloy – may be just what you're looking for.

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INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

What's new IN MATERIALS

...AT A GLANCE

A fast curing butyl rubber, introduced in the spring of 1958 (see M/DE, May '58, p 3), is now available in pilot plant quantities at a price of 35¢ per lb. The chlorine-containing material, called chlorobutyl rubber, is said to have better heat and ozone resistance than conventional butyl. Full scale production of the new material is expected in early 1960. (More details next month.)

Source: Enjay Co., Inc., Market Development Div., 1141 E. Jersey St., Elizabeth, N. J.

The largest closed-die forgings of copper ever made, it is claimed, are now being used as nose cones on the Air Force's Atlas ICBM and IRBM missiles. The forgings measure more than 5 ft in dia, 2 ft deep, 1¼ in. thick, and weigh nearly one ton each. Copper is forged in one pass on a hydraulically operated closed die forging press that exerts up to 50,000 tons squeezing power. The copper used in the forgings has a minimum purity of 99.9%. (More details next month.)

Source: Wyman-Gordon Co., 105 Madison St., Worcester, Mass.

Extremely large closed-die forgings weighing over 22,000 lb are being turned out on what is reported to be the world's largest closed impression die forging hammer. The forging tool uses octagonal or round closed impression dies in sizes up to 96 in. in dia and rectangular dies up to 72 in. wide by 200 in. long. The hammer exerts a force of over 100,000 tons at the moment of impact.

Source: Ladish Co., 5481 S. Packard Ave., Cudahy, Wis.

Continuous production of reinforced thermosetting plastics tubing is made possible by a new process developed in France. According to the developer, layers of polyester-impregnated fiberglass fabric are formed into rigid tubing in a few seconds by a new "high frequency polymerization" method. The tubemaking unit can be used in the plant or mounted on a truck and used in the field. (More details in a forthcoming issue.)

Source: Council on Public Relations, Inc., 366 Madison Ave., New York 17.

A new grade of oriented electrical steel is now in production. The steel, composition of which has not been revealed, is said to permit redesign of transformers to smaller sizes. Its core loss limit (0.58 w per lb) is said to be about 10% better than that of the best electrical steel now available.

Source: Armco Steel Corp., Middletown, Ohio.

A cobalt alloy spring material for use at 1400 F is now available. Like the existing cobalt spring alloy, Elgiloy, it is nonmagnetic. The new alloy has a tensile strength of 200,000 to 240,000 psi and an elongation of 4 to 8%.

Source: National-Standard Co., Howard & 8th Sts., Niles, Mich.

Two 'anti-dust,' injection molding grade polyethylene resins, somewhat similar to the "low static" polystyrene resins discussed in the Dec '58 issue of this magazine (p 148), have been developed. According to the developer, products made of the

compounds do not retain dust-attracting static electricity. One of the new compounds, believed to be an acrylate copolymer, has excellent low temperature toughness (see M/DE, July '59, p 137).

Source: Union Carbide Plastics Co., Div. of Union Carbide Corp., 420 Lexington Ave., New York 17.

Free-cutting sulfur copper alloy rod may compete with presently used leaded or tellurium copper rod in a number of applications. The new rod has these advantages: 1) it sells for 2¢ per lb less than tellurium copper rod, 2) its scrap is worth 6½¢ per lb more than tellurium copper, and 3) it has better hot and cold working properties than leaded and tellurium copper rod.

Source: Bridgeport Brass Co., 30 Grand St., Bridgeport, Conn.

Look for increased use of adhesives in the fabrication of consumer products. Such products as tin cans, automobiles, cameras, optical equipment, plumbing, steel piping, curtain walls, roofing and appliances are presently or will soon be bonded with adhesives. New adhesives on the way will have improved resistance to high temperatures, water, weathering, solvents, oils and greases. Some of these new adhesives might be used on greasy or dirty surfaces, thus making it easy for application in the field.

Source: C. W. Cooper and H. N. Johnston, Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio.

Aluminum castings and forgings with hard and wear resistant welds are made possible by new aluminum welding alloys. One of the alloys (four are now being tested) provides a hardness of 250 Bhn at room temperature. The aluminum welds are said to retain their high hardness and good wear resistance at high temperatures. Piston ring grooves, brake drums and valve seats are major prospects for the welding alloys. (More details next month.)

Source: Aluminum Co. of America, 1501 Alcoa Bldg., Pittsburgh 19.

An asbestos-reinforced fluoro-elastomer gasketing material is now available for high temperature sealing applications. The reinforced material, Viton rubber, is said to retain its dimensions and properties after exposure to temperatures up to 800 F. It is supplied in thicknesses from 0.015 to 0.125 in.

Source: Rogers Corp., Rogers, Conn.

A 70-30 copper-nickel alloy for heat exchanger tubes has the proper combination of strength, ductility and stress corrosion resistance to make it suitable for unfired pressure vessel use at temperatures up to 850-900 F. The developer says the alloy should be considered for inclusion in a revision of ASTM B-111 for copper and copper-alloy seamless condenser tubes and ferrule stock. (More details in a forthcoming issue.)

Source: W. F. Simmons, High-Temperature Metals Research Div., Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio.

Plastics could be improved by processing in an electrical field. Preliminary tests show that the tensile strength of polystyrene is increased approximately 25%. Elasticity, tear strength and some electrical properties might also be increased. Other plastics that might be improved by electrical field processing are polyethylene and vinylidene chloride.

Source: Illinois Institute of Technology, 35 W. 33rd St., Chicago 16.

Turn to page 133 for more "What's New in Materials"

Another new development using

B.F.Goodrich Chemical *raw materials*

These tool handles are molded in various colors by Fawick Flexi-Grip Company, Akron, Ohio. B.F.Goodrich Chemical Company supplies the Hycar nitrile rubber.

Handles of Hycar help tool users come to grips with grease problems

These colorful tool grips are molded especially for use in gas stations, machine shops and maintenance areas. Unlike handles molded with conventional rubber, they won't get soft and sticky in shop use. Hycar nitrile rubber resists oil, gas, chemicals and solvents.

Hycar wears and wears because of its toughness and unusual abrasion resistance. It's no wonder that since they've started equipping tools with handles of Hycar, tool makers are experiencing measurable increases in sales.

Hycar nitrile rubber has wide application wherever gas, oil or chemicals may be a problem—or wherever you need extra abrasion resistance, strength or flexibility. There are many different types of Hycar rubber available—in latex form as well as dry rubber. For more information, write Dept. CL-4, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

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Photo courtesy of National Screw & Mfg. Co.

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MATERIALS AT WORK

...AT A GLANCE

Honeycomb construction makes rugged door

The special qualities of honeycomb sandwich construction are being used to good advantage in a new kind of seamless hollow metal door. The door, made by permanently bonding a resin-impregnated kraft paper honeycomb core to steel skins, is said to be many times stronger than conventional steel channel reinforcement-type doors. Slammed 226,500 times with a force equal to 30 lb, the door not only exhibited excellent impact resistance, but remained "as flat as a billiard table." The doors are also said to be sound resistant.

Source: Steelcraft Mfg. Co.

Superalloy tubing replaces stainless in jets

Two cobalt-base alloys have replaced types 301 and 347 stainless steels for fuel lines and spray bars used in afterburners of jet engines. The alloys, N-155 and Haynes No. 25, were selected because the previously used steels did not possess sufficient oxidation resistance and high temperature strength. The N-155 alloy is specified for applications requiring resistance to temperatures up to 1300 F; Haynes No. 25 alloy is specified for temperatures up to 1800 F.

Source: Superior Tube Co.; used by Parker-Hannifin Corp.

First linear polyethylene telephone cable

High density polyethylene is now being used for telephone cable. The cable, which contains 26 pairs of wires, is designed for portable switchboard equipment and is expected to be used either on poles, on the ground (where it will be exposed to vehicular traffic), or under water. High density polyethylene was selected because it provides the required toughness, impact strength, stiffness and electrical resistivity.

Source: Union Carbide Plastics Co., Div. of Union Carbide Corp.; cable used by U. S. Army Signal Corps.; supplied by Phalo Plastics Co. and Plastic Wire & Cable Co.

Special tool steel increases die life

The switch from a conventional tool steel to Potomac M (a special tool steel containing 5% chromium and 1% vanadium) has resulted in a two year increase in the life of dies used in an aluminum die casting operation. Potomac M was selected because it provides excellent toughness and resistance to wear at elevated temperatures. The dies are used to produce electric heater motors by centrifugally die casting aluminum around rotor laminations. The previously used dies lasted an average of 24 hr; the new dies last up to two years.

Source: Allegheny Ludlum Steel Corp.; dies used by Arvin Industries, Inc.

Neoprene jacketing for missile cable

Specially compounded neoprene is replacing natural rubber for jackets of multi-conductor missile cable. Reason: it provides superior resistance to oil, ozone, and sunlight; is capable of operating at temperatures ranging from –65 to 125 F; and provides the required tensile, impact and elongation properties.

Source: E. I. du Pont de Nemours & Co.

Stainless steel ribbon makes good filter

Type 304 stainless steel ribbon spirally wound into a cylindrical form is the heart of a new metal-edge filter used in missiles and nuclear reactors. Stainless was selected because it satisfied the three major

(continued on p 9)

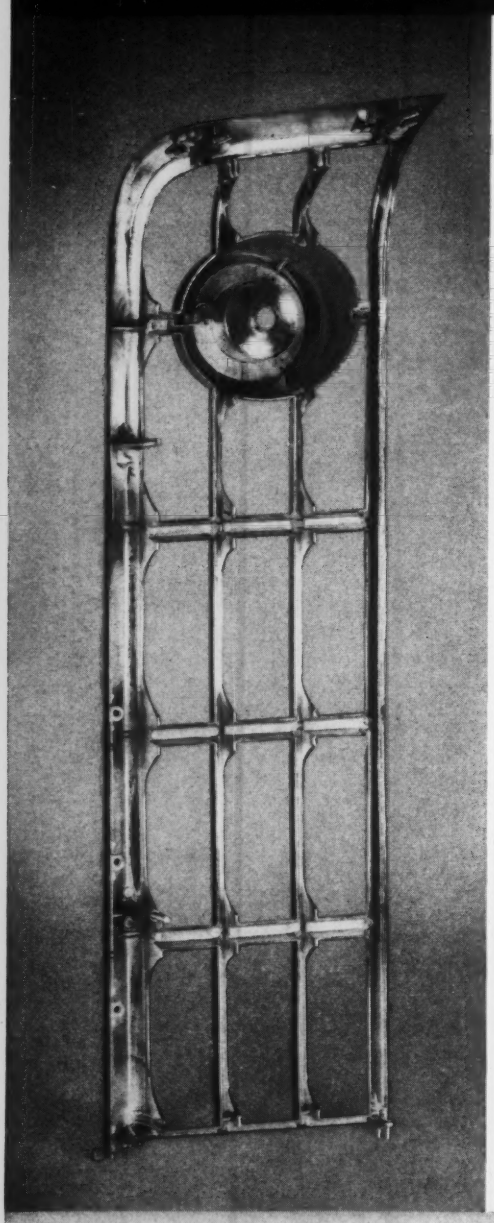
Briefs

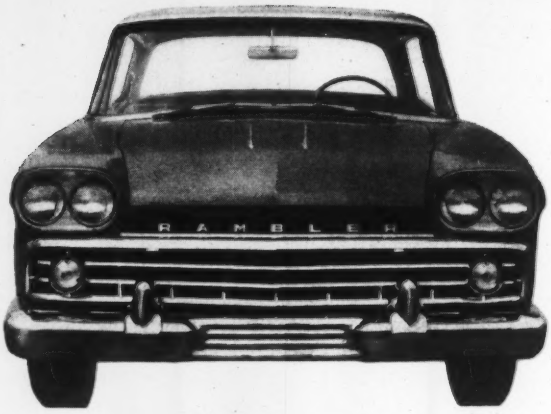
Atomic lamps that shine for years may soon be a reality. The lamps, almost ready for commercial production, are filled with radioactive materials (particularly gaseous isotopes such as tritium and krypton 85) which emit beta particles to activate a phosphorus coating.

Nylon-centered golf balls are said to add 10 to 20 yd to the average drive. The balls, which meet all regulations, are also said to maintain their shape after prolonged use. Unfortunately, they do not prevent slicing.

Drafting pens are now being made with tungsten carbide points for use on materials with extremely hard surfaces.

IT'S LIGHTER THAN YOU THINK!





...AND MAKES A STRONGER GRILLE WHEN DIE CAST with ZAMAK

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Complete with integrally cast lamp housings and mounting studs for rapid assembly, the grille on this popular American Motors automobile is designed for appearance, durability and economy.

As in many other applications, rugged but extremely thin wall sections—possible only with ZINC die castings—minimize weight and are stronger **in proportion to thickness** than heavier sections.

Parts designed for ZAMAK alloy die casting will meet competition of either stampings or aluminum castings—and at lower cost.

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requirements: 1) resistance to corrosion and temperature changes; 2) ability to be both welded and formed; and 3) ability to hold close tolerances on filter orifices. To make the filter, several yards of the ribbon (which has a trapezoidal cross section) are wound spirally in layers and resistance welded.
Source: Purolator Products, Inc.

PVC piping better than metal for plating

The selection of rigid polyvinyl chloride pipe and fittings in preference to metal has eliminated a number of problems in a plating operation. About 2000 ft of ¾ to 2-in. piping are used to carry solutions of chloride, sulfur dioxide and various alkalis and acids at temperatures ranging from 60 to 130 F and pressures from atmospheric to 60 psi. Advantages claimed for the PVC piping are: elimination of scale; resistance to corrosion; light weight; low cost; elimination of galvanic or electrolytic action; excellent insulating properties; and long life.
Source: Tube Turns Plastics, Inc.; piping used by International Business Machines Corp.

Magnesium-thorium alloys in missiles

Magnesium-thorium alloys account for about 35-50% of the total weight of Discoverer satellites and about 40% of the skin structure of the Titan ICBM. The alloys, used in the form of sheet, extrusions, forgings and castings, were selected because they are lightweight and offer good resistance to aerodynamic heating (up to 900 F), wide temperature variations and compressive buckling.
Source: Dow Chemical Co.; Discoverer manufactured by Lockheed Aircraft Corp.; Titan manufactured by Martin Co.

Vinyl coatings cut railroad car maintenance

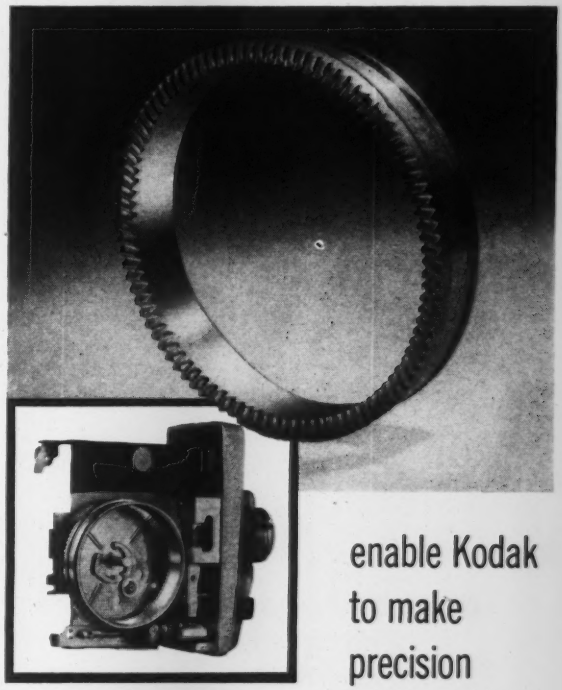
Vinyl coatings are now protecting railroad hopper cars. The coatings, said to be fast drying and easy to apply, provide excellent protection against such cargo materials as cement, bauxite, soda ash and potash. In addition, the coatings are resistant to chemicals and weathering and should enable cars to remain in service for several years without repainting.
Source: Union Carbide Plastics Co., Div. of Union Carbide Corp.; coatings produced by Paint & Brush Div., Pittsburgh Plate Glass Co.

Welded tubing replaces seamless in jacks

The switch from seamless to electric resistance welded tubing with a special smooth i.d. has resulted in improved performance and reduced manufacturing costs of hydraulic jacks. The welded tubing, supplied in 20-ft lengths, is cut to size and beveled in one operation and, except for threading, requires no further processing. Previously used seamless tubing often had to be refinished inside in order to meet rigid specifications.
Source: Jones & Laughlin Steel Corp.; used by Hein-Warner Corp.

(more Materials at Work on next page)

ECONOMIES SUCH AS THIS...



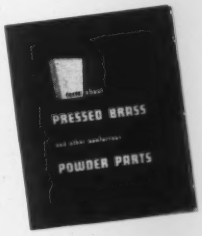
enable Kodak to make precision cameras at the lowest possible price

Eastman Kodak Company switched to **BRASS POWDER METALLURGY** for the motor face gear on the Kodak Medallion 8mm Movie Camera—saving machining and gear cutting.

OTHER MATERIALS either would not take the stress of motor overwind, were too costly to machine, lacked required concentricity or generated 75% process scrap.

THE BRASS POWDER PART*... *eliminated gear cutting...reduced machining to a minimum...produced no scrap... had more than required strength...perfect concentricity ...AND LOW COST.*

*made by The Presmet Corp., Worcester, Mass.



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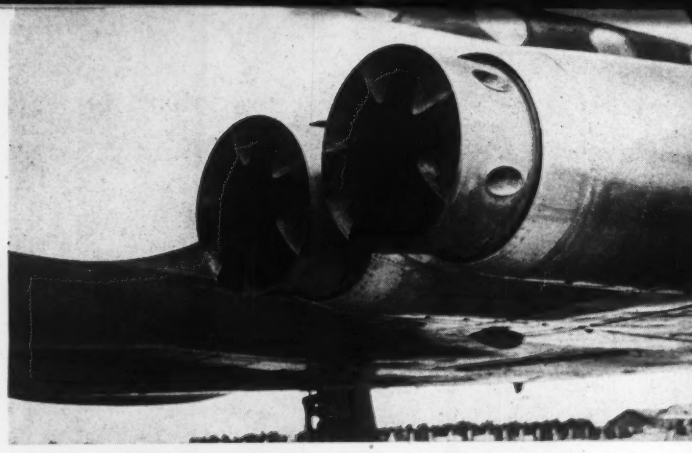
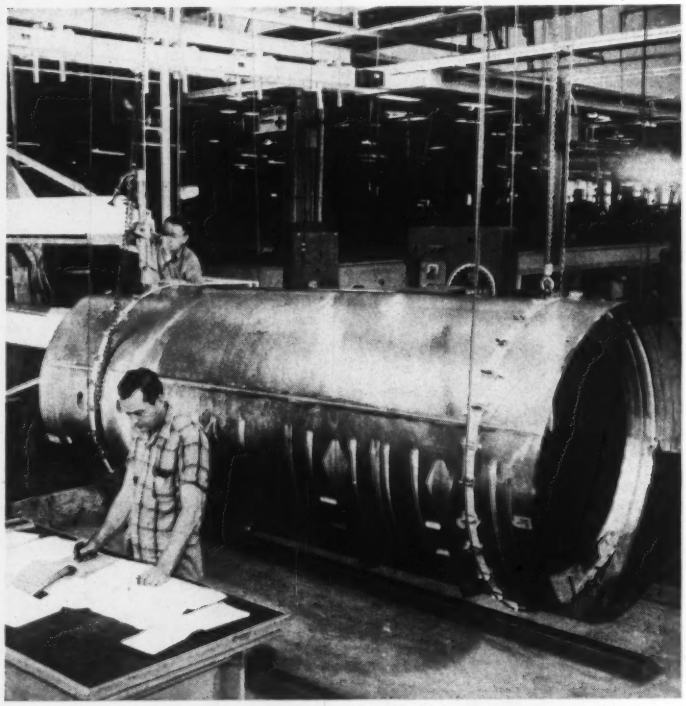


Jet engine silencers, used to reduce noise on BOAC's Comet 4, are made of Nimonic 80A nickel-chromium alloy. The silencers, which are actually corrugated nozzles, reduce noise by slowing the jet stream and thus decreasing shock waves caused by the shearing effect of fast moving gases. Nimonic 80A was selected because it provides excellent strength plus corrosion and oxidation resistance at high temperatures.

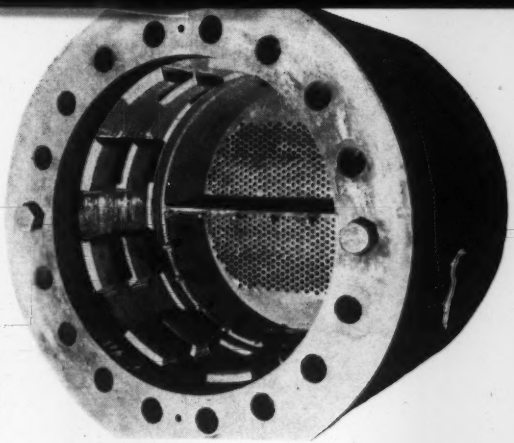
Nickel alloys solve high temperature problems

The use of nickel and nickel-base alloys has continued to grow as operating temperatures push ever higher. The accompanying photos (submitted by International Nickel Co.) show several current uses of nickel alloys. For more details on some of these alloys, see M/DE, Sept '57, p 115.

Carbon arc lamp uses four nickel alloys to withstand intense 8000 F heat: 1) *Inconel plate* used to shield internal parts from direct heat of arc—selected because of its high temperature strength and corrosion resistance; 2) *electronic grade A nickel* used for the split disk brush which holds the carbon electrode—selected because of its low contact resistance, good electrical conductivity, ease of welding, and high resistance to corrosion and oxidation at high temperature; 3) *Inconel helical springs* used to maintain pressure of disks on electrode; and 4) *four monel-copper alloy bolts* used to hold assembly together.



X-15 rocket plane, scheduled to carry a man 100 miles into space at speeds up to 3600 mph, uses age hardenable Inconel X for surface skins, wings, and fuel cylinders (see photo at right). Inconel X was selected because it provides good strength at 1000 F (the temperature expected during re-entry), excellent resistance to thermal fatigue, and high creep strength.



Feedwater boiler, which converts water to superheated steam without the use of steam drums, uses 456 U-shaped monel tubes (see photo at right). Water passes only once through the continuous tubing and emerges from the final stage at 489 F. The heater has a design pressure of 4300 psi on the tube side; temperature of the tube metal reaches 600 F. Monel was selected because it "has the highest allowable design stress of any alloy suitable for this application," thus permitting the thinnest tube wall for efficient heat transfer. In addition, it has sufficient ductility to be rolled into steel tube sheets (see photo above).

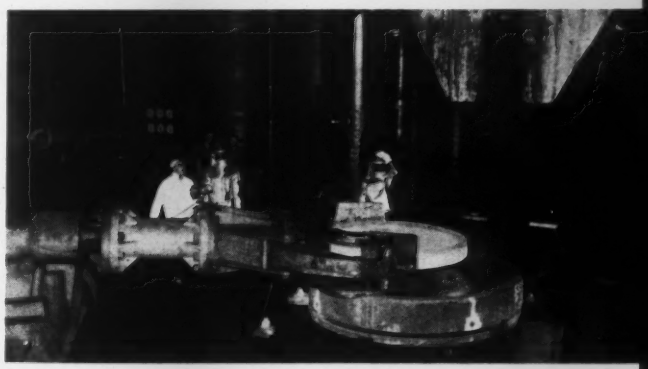
Edited by Walter Lubars

Forged beryllium heat shield

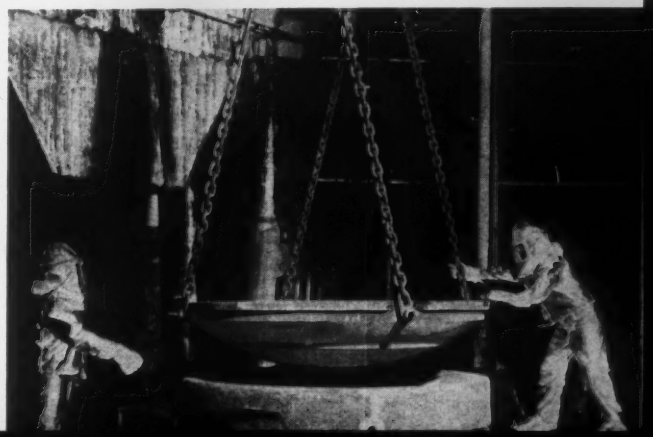
The huge beryllium heat shield that will form the outside covering of the "floor" of the first manned space capsule (see M/DE, Aug '59, p 186) has been successfully forged by Aluminum Co. of America.

While in orbit and during its return to earth, the capsule will be positioned so that the beryllium shield becomes the leading face, thereby absorbing and dissipating the tremendous heat generated by air friction.

To produce the shield (or heat sink), Brush Beryllium Corp. first pressed what is said to be one of the largest beryllium billets ever made by powder metallurgy (62 in. in dia and 5 in. thick). After preliminary machining, the billet was sent to Alcoa where it was encased in steel and heated to 2000 F. A huge manipulator then placed the billet in a preheated die in a 50,000-ton press where it was squeezed into a saucer-shaped disk 80 in. in dia and 3 in. thick (see photos). The part was then returned to Brush Beryllium for finish machining to 72-in. dia.

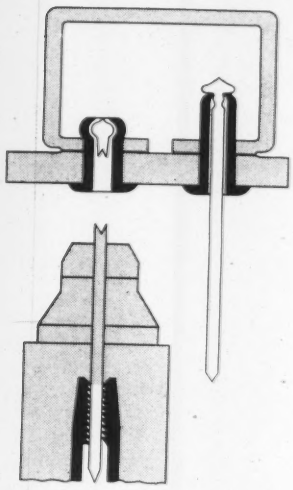


Beryllium billet is put in preheated die . . .



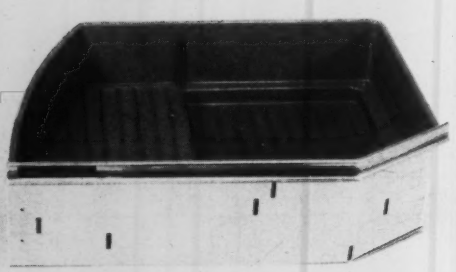
. . . and forged into saucer-shaped disk.

Riveting plus adhesive bonding *is used on laminated boat hulls.*



To set rivet: *pull mandrel through hollow cylinder*

Riveting plastics is fast, economical



Refrigerator crisper tray *with trim riveted to molded housing.*

The recent development of new techniques and lightweight tools has led to wider use of riveting as a basic method of joining plastics structures and products. One of these techniques, "Pop" riveting, is said to offer several advantages over many joining techniques now in use.

As shown in the sketch above, the rivet consists of a headed, thick-walled hollow metal cylinder and an internal mandrel having a preformed notch. When the mandrel is pulled by the riveting tool, it squeezes the rivet together, breaks off at a predetermined setting force, and provides a positive locking action.

Advantages

According to Pop Rivet Div., United Shoe Machinery Corp., Pop riveting eliminates the three major drawbacks which up to now limited the use of riveting for plastics: 1) damage caused by the setting force; 2) slow operating speed; and 3) difficulty of manipulation.

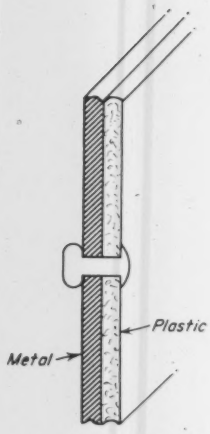
Specific advantages of Pop riveting are:

1. *Low tool cost*—Because the tools are usually made by the company interested in selling rivets, they are exceptionally inexpensive.

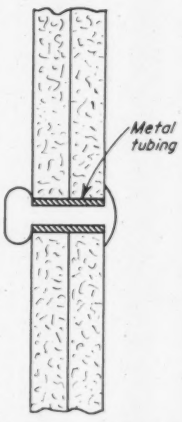
2. *Simplicity*—Untrained operators can be employed, visual inspection

(continued on p 195)

Two design tips for pop riveting . . .



plastic-metal



compressible materials

MORE MATERIALS AT WORK

Wire tire resists 2000 F.... 195
Wining designs in powder metallurgy 196
Combination casting produces undercuts..... 198
Pyroceram bearings resist hot corrosives 200
Molybdenum cores best for die casting 202
Acrylic reel cover replaces aluminum 204

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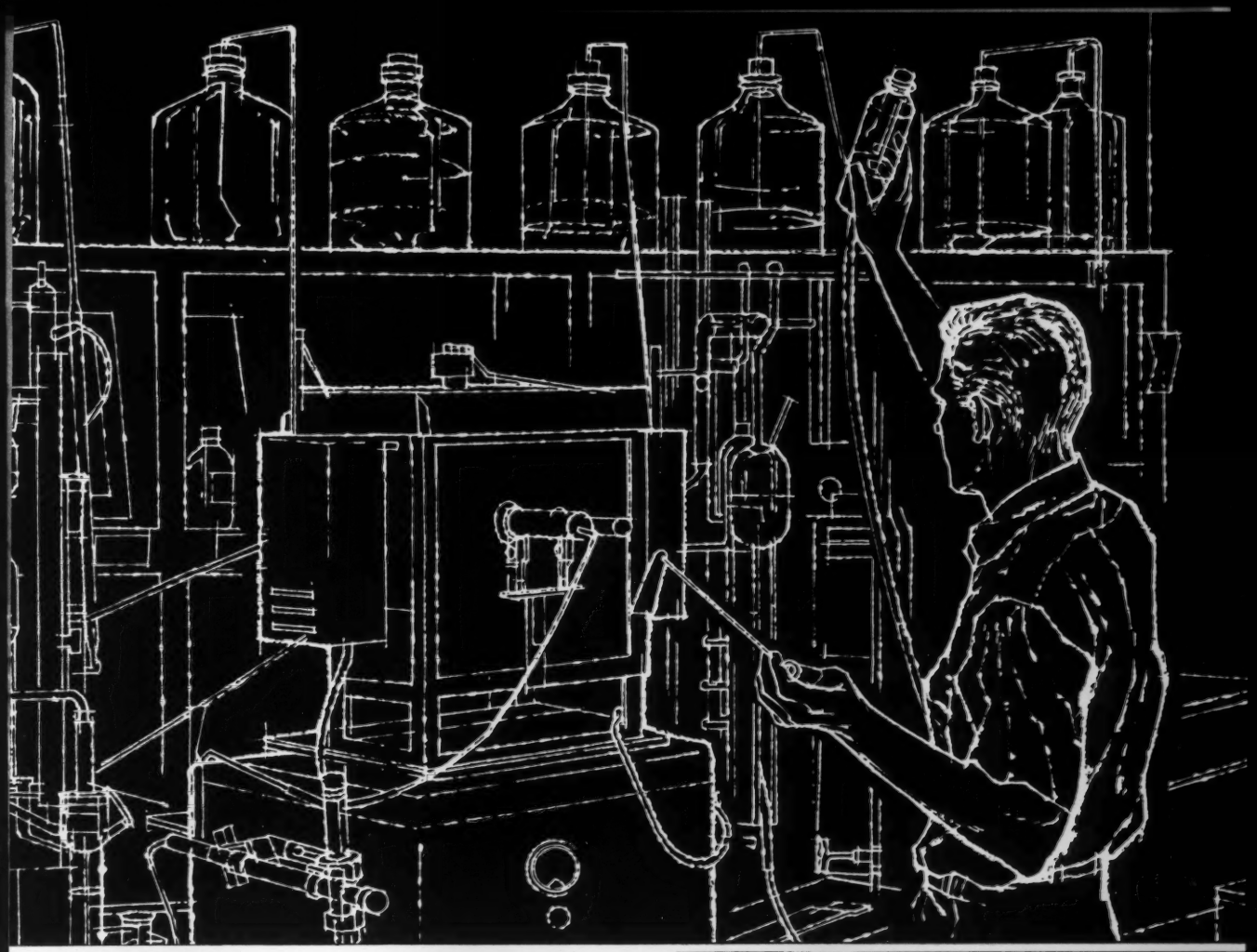

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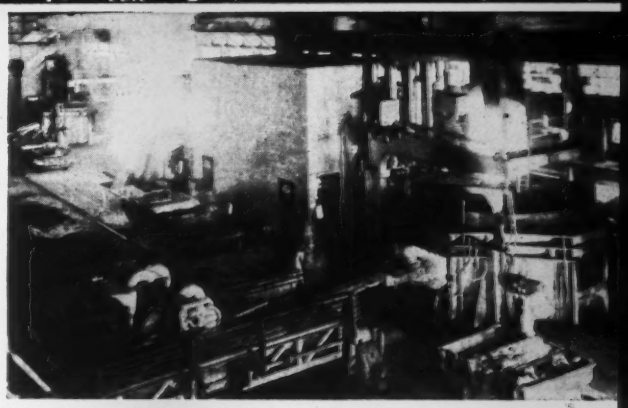

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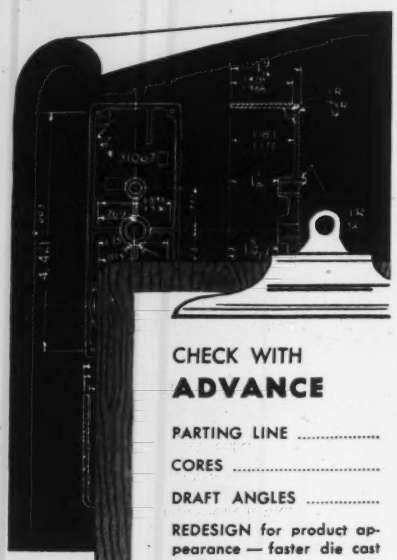

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Correction: stainless steel, not aluminum . . .

To the Editor:

Please refer to "The New 5xxx Aluminum Alloys" by R. T. Meyer and D. R. Cheyney of Kaiser Aluminum & Chemical Corp., July '59, p 91. The lead photograph caption reads "Portable storage tank for liquid oxygen takes advantage of the low temperature strength of the 5000 series." The same photo was used in a recent Kaiser Corp. ad and the caption read, in part, "Double-shelled mobile liquid oxygen tank, produced with Kaiser Aluminum Alloy 5086."

A reader is thus led to conclude that the tank uses aluminum to withstand the liquid oxygen. We suspect that such is not the case. We believe the tank has an *outer* jacket of 5086 aluminum alloy and an *inner* shell of type 321 chromium-nickel stainless steel.

The full effects of the low temperature, and the responsibility for protecting the contents from corrosion products, are borne by the stainless steel. It is unfortunate that the vital contribution made by type 321 has been ascribed to the aluminum alloy by implication.

W. S. MOUNCE
Supervisor, Development and Research Div.
International Nickel Co., Inc.
New York, N. Y.

The caption submitted by the authors read: "Portable liquid oxygen storage tank for missile service." We were guilty of an erroneous deduction in adding ". . . takes advantage of the low temperature strength of the 5000 series." However, the comments below from Kaiser Corp. shed further light.

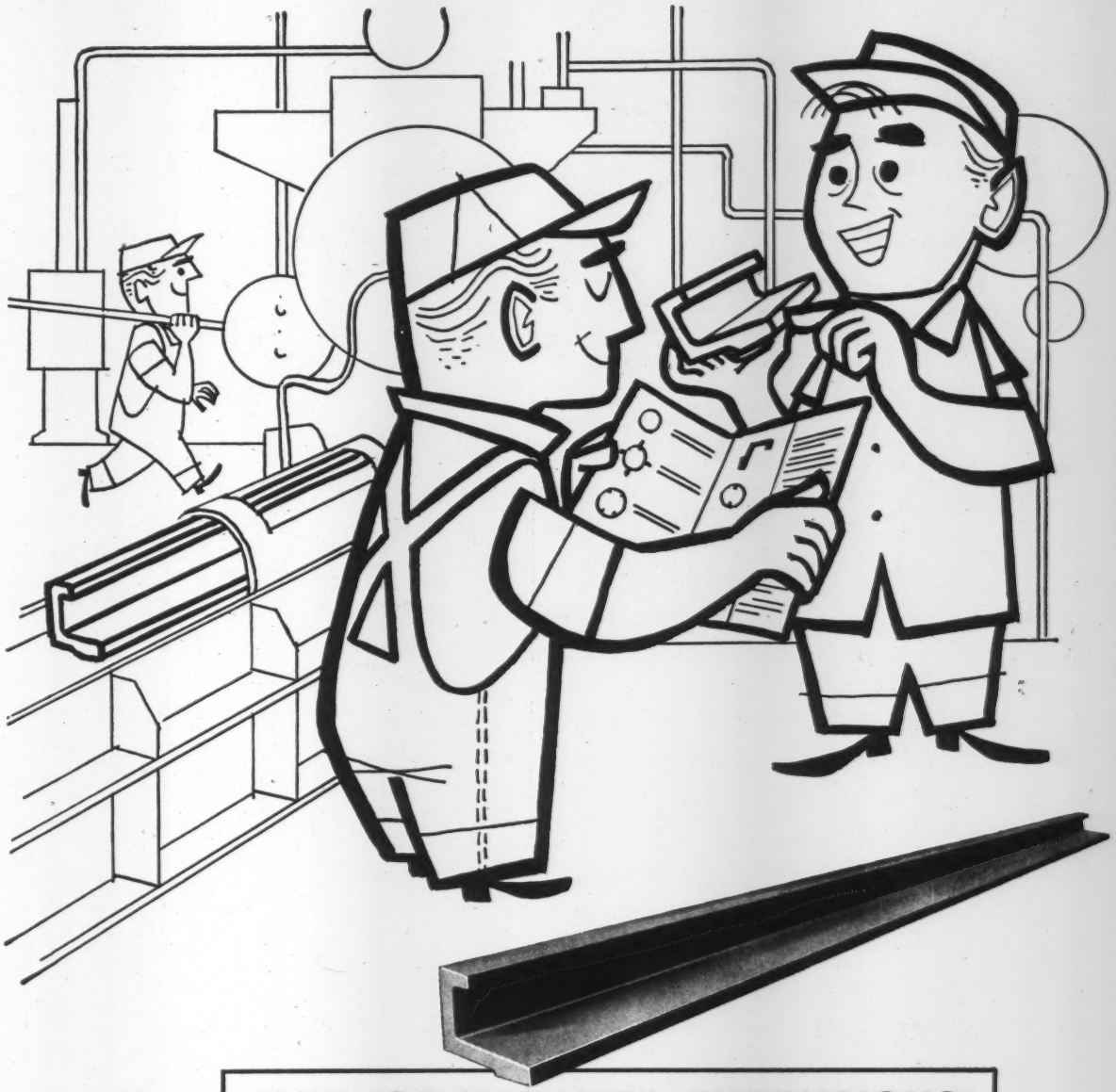
. . . but sometimes aluminum also

To the Editor:

On further checking we find that in the particular storage tank shown, the inner shell was fabricated from stainless steel while the outer shell is aluminum alloy 5086. However, it is a fact that many storage tanks, both mobile and stationary, as well as processing vessels for liquefied gases, employ the 5000 series of alloys for their inner shells. It is notable that welded aluminum plate has been used for the inner shells of two 25,000,000-cu ft storage spheres at a new plant erected by the Linde Co. at Pittsburg, Calif., to produce liquid oxygen and nitrogen—an application where aluminum's light weight was not a contributing factor.

DUDLEY T. ROSS
Manager, Press Section
Kaiser Aluminum & Chemical Corp.
Oakland, Calif.

(more Letters on p 16)



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(cont'd from p 14)

Standard bend radii questioned . . .

To the Editor:

This refers to "How to Evaluate Formability of Sheet Metal," Dec '58, p 100. Having had considerable experience in this particular field, I am rather disturbed by the information presented.

For instance, the improved bend test fixture, a hydraulic tester using narrow strips of samples, is shown as a method for determining formability. Unfortunately bend radii derived by this method are of little value since they do not take into account the length factor, which imposes triaxial stresses, and the speed of forming. My tests have shown that a bend specimen 6 in. in length may be acceptable and bend satisfactorily to a minimum radius, yet the same specimen 12 ft long fails.

Also, hydraulic bending does not reproduce shop conditions, since the speed and impact are different. For instance, I have been able to form a 2014-T6 extrusion, which has an elongation factor of 7%, by means of hydraulic pressure to result in an elongation of 32% without fracturing or orange peeling. These results are only possible under controlled conditions, but tests for formability should be made under shop conditions.

Instead of the Olsen cupping test, a more realistic test is one where a standard punch press is used and blanks are prepared for different ratios of blank vs. punch die; also depth of draw is controllable by adjusting the stroke of the press.

The practice of setting up bend radii tables based on grain direction is not practical since it is very difficult to control the cutting of materials in the shop with these requirements. Experience in the aircraft industry has shown that minimum bend radii result in high cost and that too much importance is attached to them. A standard bend radius which is more liberal and not held so close to the fracturing point is more easily manufactured and less costly to reproduce.

Edge preparation is an important factor when bending to minimum radii because a burred edge results in a notch effect, initiating cracks more readily then when the same edge is deburred or in some cases polished. The forming of beads involves complex stresses which cannot be determined by a simple bend test. Forming of bends requires a combination of reverse bending, stretching and deep drawing. Elongation factors are usually lower than that for standard bend radii. Types and methods of lubrication also play an important role, affecting the coefficient of friction.

BERNHARD ROGGE, Design Engineer
Army Chemical Corps
Baldwin, Md.

. . . and answered

I feel that Mr. Rogge has missed the main purpose of our tests. We found them very valuable for predicting the formability of the constantly changing group of alloys used in the jet engine

(continued on p 193)

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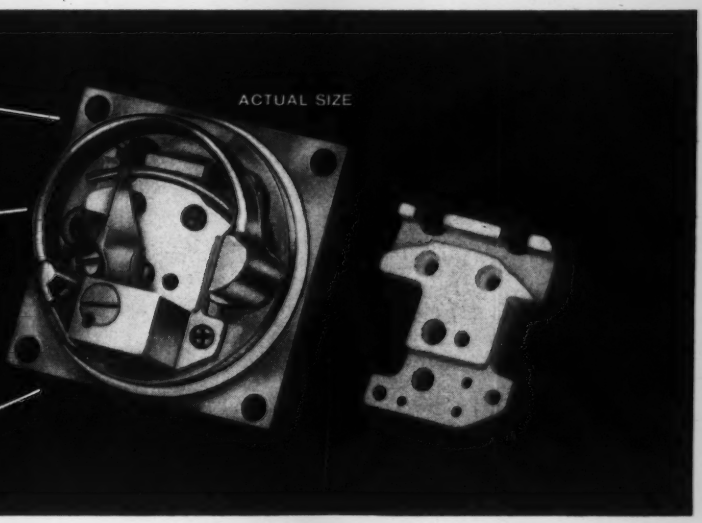

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PRICES AND SUPPLY

...AT A GLANCE

More small diameter tubing will be available as a result of a multi-million dollar expansion program soon to be completed by J. Bishop & Co. Platinum Works. The first stage of the program, completed Aug 30, put into operation a new plant for redrawing small diameter (0.008-1 in.) stainless, nickel and superalloy tubing.

Polycarbonate plastics may be commercially available sooner than expected. In a surprise announcement, Mobay Chemical Co. indicated that its new plant in New Martinsville, W. Va. will be on stream with polycarbonate plastics by the spring of 1960—three months ahead of General Electric Co.'s target date. Mobay's plant will probably be about the same size as GE's, which is said to have a capacity of 10 million pounds per year.

Aluminum is now being stocked by Joseph T. Ryerson & Son, Inc., one of the country's largest steel warehouses and distributors. According to Wilson A. Young, general manager, Ryerson is now able to supply aluminum in the form of bar, sheet, rod, plate, structurals, pipe and other shapes.

Man-made diamonds are now available at the same price as natural diamonds. According to Carborundum Co., abrasive wheels made of GE's synthetic diamonds cost exactly the same as those made of real diamonds. The man-made diamonds are better than the natural ones for grinding carbides.

Use of ductile iron for pipe in 1959 will reach 21,000 tons, or about three times the amount used in 1958, according to Donald J. Reese, International Nickel Co. Mr. Reese also predicts that by 1961 the figure will climb to 100,000 tons. These predictions are based on the "rapidly expanding use of this new engineering material" for water mains, underground distribution systems, and piping aboard tankers and in chemical plants.

Yearly consumption of plastics from 1958 to 1965 will increase at a rate of 9.3% per year, predicts A. F. Sward, manager of market research, Union Carbide Corp. According to Mr. Sward, total plastics consumption in 1965 will be slightly over 8 billion pounds. Estimates for some specific plastics are as follows (in millions of pounds): cellulosics, 173; polystyrenes, 860; phenolics, 600; urea-melamine, 440; vinyls, 1400; polyesters, 230; and polyethylenes, 2150.

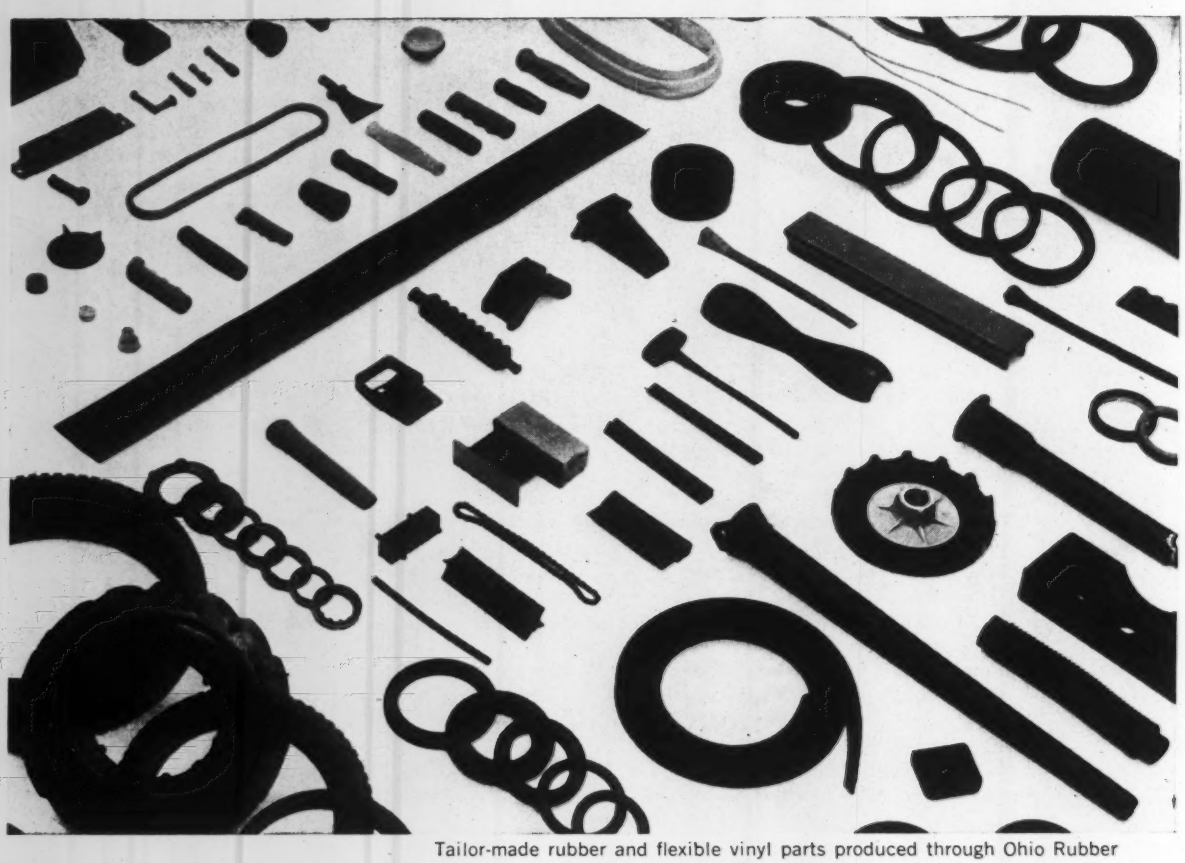
Production of super pure aluminum will be increased by Kaiser Aluminum & Chemical Corp. New refining mills, which produce aluminum with a purity of 99.99+%, will increase the company's production from 300,000 to 900,000 lb per year.

Production of Mylar polyester film will be increased substantially when Du Pont's new plant is completed early in 1961.

A substantial increase in the supply of melamine will result from an expansion program planned by American Cyanamid Co. The first result of the program will be a 10-million-pound-per-year plant to be built in Wallingford, Conn. early in 1960.

A new supplier of polymethyl methacrylate (acrylic) syrup—Escambia Chemical Corp.—will enter the field sometime in 1961 or 1962. Du Pont is the only current supplier of this syrup, used in fabricating acrylic reinforced plastic structures.

Prices of Materials on p 207



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The ORCO engineer's recommendations for feasible design modifications will further help produce a better part, frequently at big savings to you.

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Suggestion: The more complete story behind Ohio Rubber's long-standing and profitable partnerships with leading original equipment manufacturers is more fully told in ORCO Bulletin 715. Write for your free copy today! 9MP1

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Tool Steel Topics

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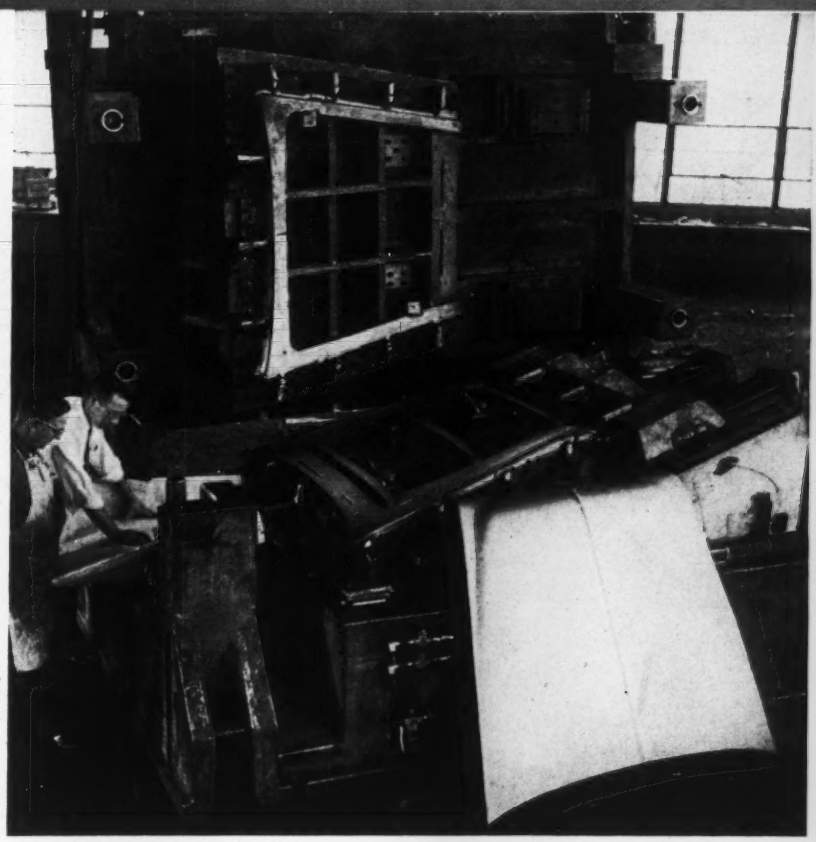

Automotive Die, in 101 Sections, Made from Water-Hardening Steel

This huge die, made up of Bethlehem W-1 carbon water-hardening tool steel, trims an automobile hood. Made from tool steel furnished by Peninsular Steel Co., Detroit, the die was photographed recently at Republic Die & Tool Company, Wayne, Mich. It contains 44 composite sections, 34 wear plates, and 23 solid sections.

Bethlehem carbon water-hardening steels were selected for this exacting application because of their good wear-resistance, easy machinability, and simple heat-treatment—plus ease of welding should repair become necessary.

Bethlehem carbon water-hardening tool steels, because of their carefully controlled hardenability, provide economical service in applications calling for high shock-resistance. And with their highly selective carbon range, they have good resistance to wear, plus the toughness to withstand cold battering.

If you have any questions about the use of Bethlehem carbon water-hardening tool steel, or any of our other popular grades, get in touch with your Bethlehem tool steel distributor. He's as near as your telephone.

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BETHLEHEM TOOL STEEL ENGINEER SAYS:

Here's How to Stabilize Gages

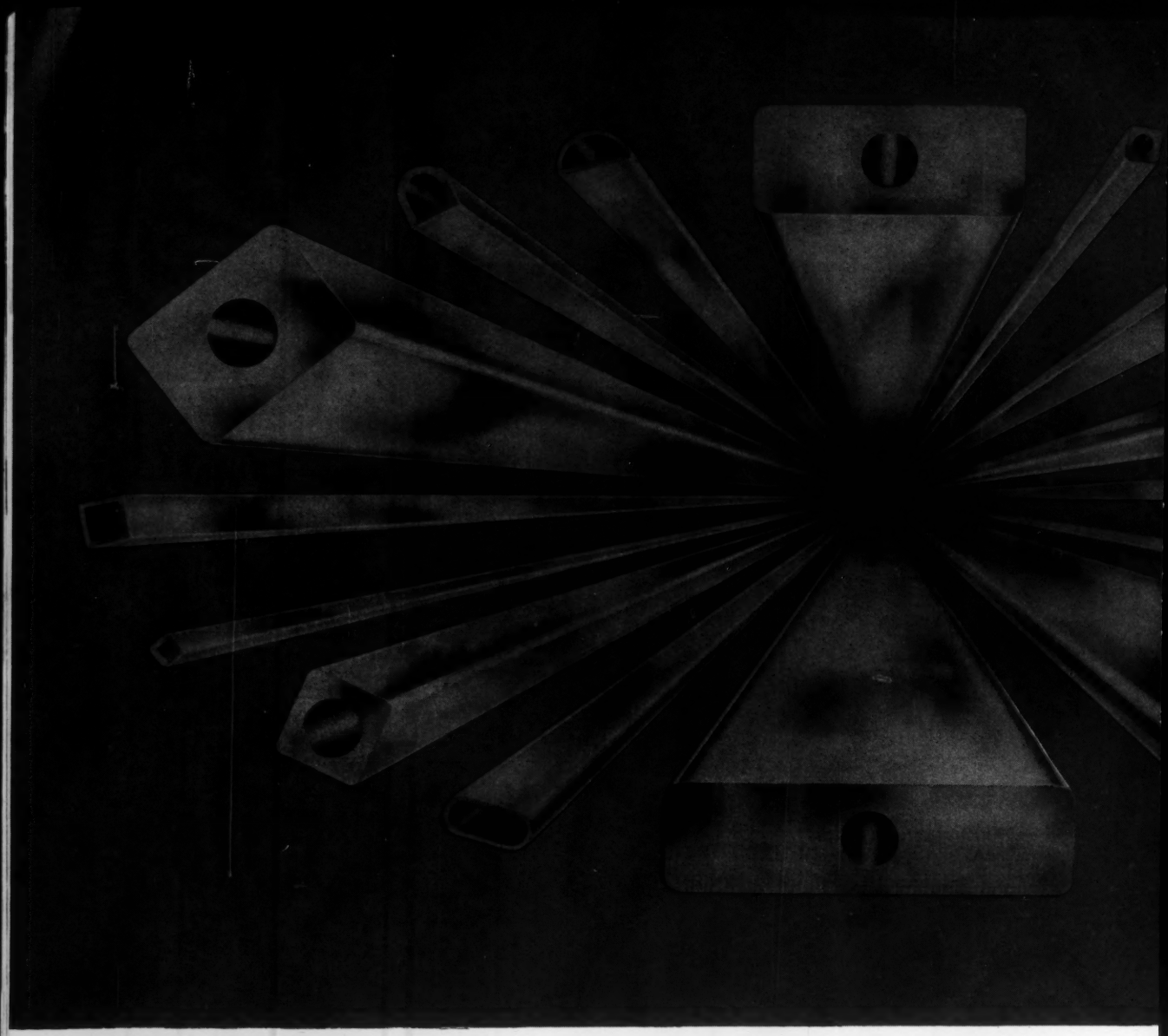
High-precision gages, commonly made of BTR tool steel (AISI Type 01), need a stabilization treatment if they are to maintain their accuracy for years. Otherwise expansion will eventually change dimensions outside of the permissible tolerance. These dimensional changes are in a magnitude of hundred-thousandths of an inch per inch, or smaller. Insignificant on ordinary tooling, they are important on precision gages.

The expansion which occurs over a period of time is due to the transformation of austenite retained during the quench for hardening. The object of the stabilization treatments is to transform the retained austenite during the treatment, so that none remains which could transform later on. This condition exists in all tool steel grades which can be hardened to Rockwell C 60 or higher.

The most common method for stabilizing high-precision BTR gages is: 1. Quench and temper in the normal manner to produce the desired hardness. 2. Rough grind. 3. Subzero cool to minus 100/120 F in refrigerator or dry ice. 4. Warm to room temperature and then retemper at original temperature. 5. Finish grind to size. 6. Repeat cycles of subzero cool followed by tempering five more times. 7. Lap or superfinish to size.

Sometimes it is possible to shorten this procedure, particularly if the design is such that there is little hazard of cracking. For example, the tools can be subzero cooled directly from the quench, with no interval at room temperature, followed by tempering and grinding. This will permit stabilization with only two additional cycles of subzero cool plus temper, but the disadvantage is that cracking may occur after quenching.

It is also possible to shorten the stabilization by cooling to minus 314 F in liquid air. This permits reducing the cycles of subzero cool plus temper to three instead of six.



THE SHAPE OF THINGS TO COME WITH ANACONDA

Fluid-cooled copper conductors. The growing need for compact electrical assemblies which can handle high current densities is leading to an ever-increasing variety of hollow, fluid-cooled copper conductors. The samples shown full size above give some idea of the range of sizes and shapes produced by The American Brass Company.

Nuclear physics magnets are, perhaps, the most spectacular applications of fluid-cooled conductors. These hollow conductors range from tube .182" square O.D. x .083" square I.D. to heavy rectangular bars with a round core for water cooling.

Industrial applications. The use of fluid-cooled conductors is growing rapidly in large electrical equipment. Generator output can be greatly increased, without increasing frame size, by cooling stator and rotor bars. Fluid-cooled conductors are being used in heat sinks for rectifiers and induction furnace coils. Another interesting use is in compact water-cooled windings needed to provide very high flux densities in, for example, the ceramic magnet manufacturing process. These "solenoids" are being built for applications in which the current range is from a few hundred to about 2000 amperes.

Technical assistance. Whatever your problem—liquid-cooled field coils, rotor bars or a special-shape tubular conductor—technical specialists at The American Brass Company can help you work out the size and shape best adapted to your needs. See your American Brass representative or write: The American Brass Company, Waterbury 20, Conn. In Canada write: Anaconda American Brass Ltd., New Toronto, Ont. 5942

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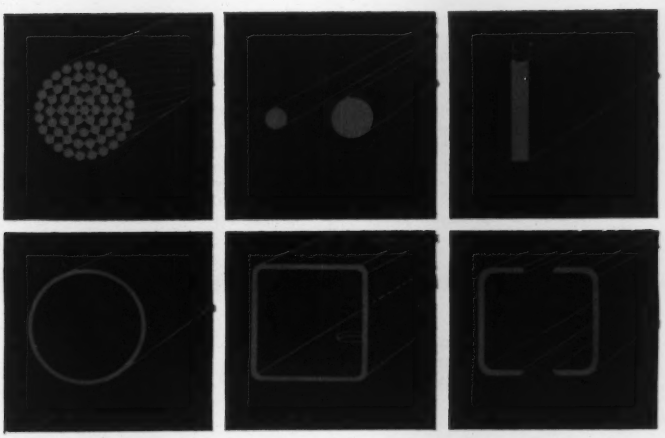

Standard Anaconda copper bus conductor shapes.

200,000 KW AT 750 VOLTS is maximum peak rating of twelve d-c generators providing power for the confining field coils in C Stellarator being built in the new fusion research facility at Princeton University. This power is needed to establish the maximum 50,000-gauss magnetic field, forming the walls around the reaction aimed at reaching 100 million degrees. A.E.C. demonstration model above shows one form of the Stellarator tube that has been considered. The big copper bus (top), 9 square inches in section and silver plated, will carry the tremendous power from the generators to the coils around the Stellarator tube. The American Brass Company has furnished the mile of bus required for the job to specifications of the Allis-Chalmers Manufacturing Co., Milwaukee, Wisc., which is assisting in the design and building of the C Stellarator.

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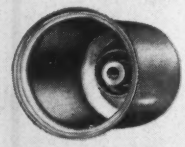
MUELLER BRASS CO. OFFERS 7 WAYS TO PRODUCE YOUR PART

Mueller Brass Co., because of its diversified manufacturing facilities that encompass a wide range of fabricating methods, is in the unique position of being able to offer you, the purchaser, an intelligent, unbiased analysis and recommendation of the best, most economical method by which your particular part can be produced. As the result of over 40 years' experience, the "Methods Analysis Department" has at its command complete knowledge of the advantages and limitations of each production process. After receiving detailed knowledge concerning the end use of the part, material specified, conditions under which it must operate and other pertinent factors, these analysis engineers make their recommendations. Every detail is considered. In many cases, methods analysis engineers recommend a simple design change that makes practical a much more economical method of production. This technical service, offered only by Mueller Brass Co., is given to each individual inquiry and is your assurance that you will get the best product at the best price . . . made the one best way . . . by Mueller Brass Co.

Send today for free technical literature on any one or all of the seven fabricating methods.

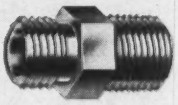
FORGINGS

Production equipment is available to produce press, hammer or cored forgings of any practical shape in sizes ranging from a few ounces to 150 lbs. in brass, bronze, aluminum and magnesium in 27 standard, as well as special, alloys.



COLD-PREST® IMPACT EXTRUSIONS

Mueller Brass Co. has complete machinery for producing Cold-Prest impact extrusions of aluminum, copper, brass, bronze and steel. Extrusions up to 28" in length are possible, depending on wall thickness and other design details. Parts can be designed having ribs, flutes, splines or bosses . . . with multiple wall diameters and with uniform or tapered wall sections.



SCREW MACHINE PRODUCTS

Mueller Brass Co. has one of the world's largest automatic screw machine departments fabricating both ferrous and non-ferrous custom parts. We can produce an infinite variety of shapes and sizes from ⅛" to 3¼" in wide range of free cutting and specialized alloys. Complete facilities for all secondary and finishing operations, as well.

POWDER METAL PARTS

Mueller Brass Co. can supply precision Sinteel® powder-metal parts in wide range of sizes and metals at high production rate. Parts available from iron, brass and copper alloys. Parts may be ordered with such characteristics as self-lubrication, controlled porosity and good electrical and magnetic properties.

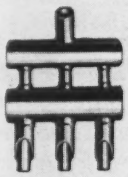
MADE IN U.S.A. TO THE STANDARDS OF AMERICAN INDUSTRY

MUELLER BRASS CO.

...and our methods analysis service helps you determine which is the best ...and most economical method

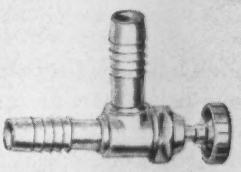
SAND CASTINGS

We specialize in the production of pressure-tight red brass castings. We utilize both metal match plate and wood patterns. Facilities include tool room and pattern shop, electric melting furnaces, high capacity core room and both bench and floor molding equipment to handle wide range of sizes.



FORMED COPPER TUBE

Mueller Brass Co. has modern facilities for forming seamless copper tube into a multitude of shapes. Forming methods used include bending, spinning, expanding or swedging, upsetting, flaring, flattening, beading and grooving, drilling and piercing, machining and joining. Formed copper tube coils are also available as single, double, spiral and serpentine shapes.



PLASTIC INJECTION MOLDING

Injection molding of plastic parts is still another process offered by the Mueller Brass Co. Parts are molded from such plastics as—nylon, polyethylenes, polyvinyl chloride, styrenes, linear acetal, chlorinated polyether, polycarbonates or polypropylene, dependent on part application.

MAN FROM MUELLER BRASS CO.

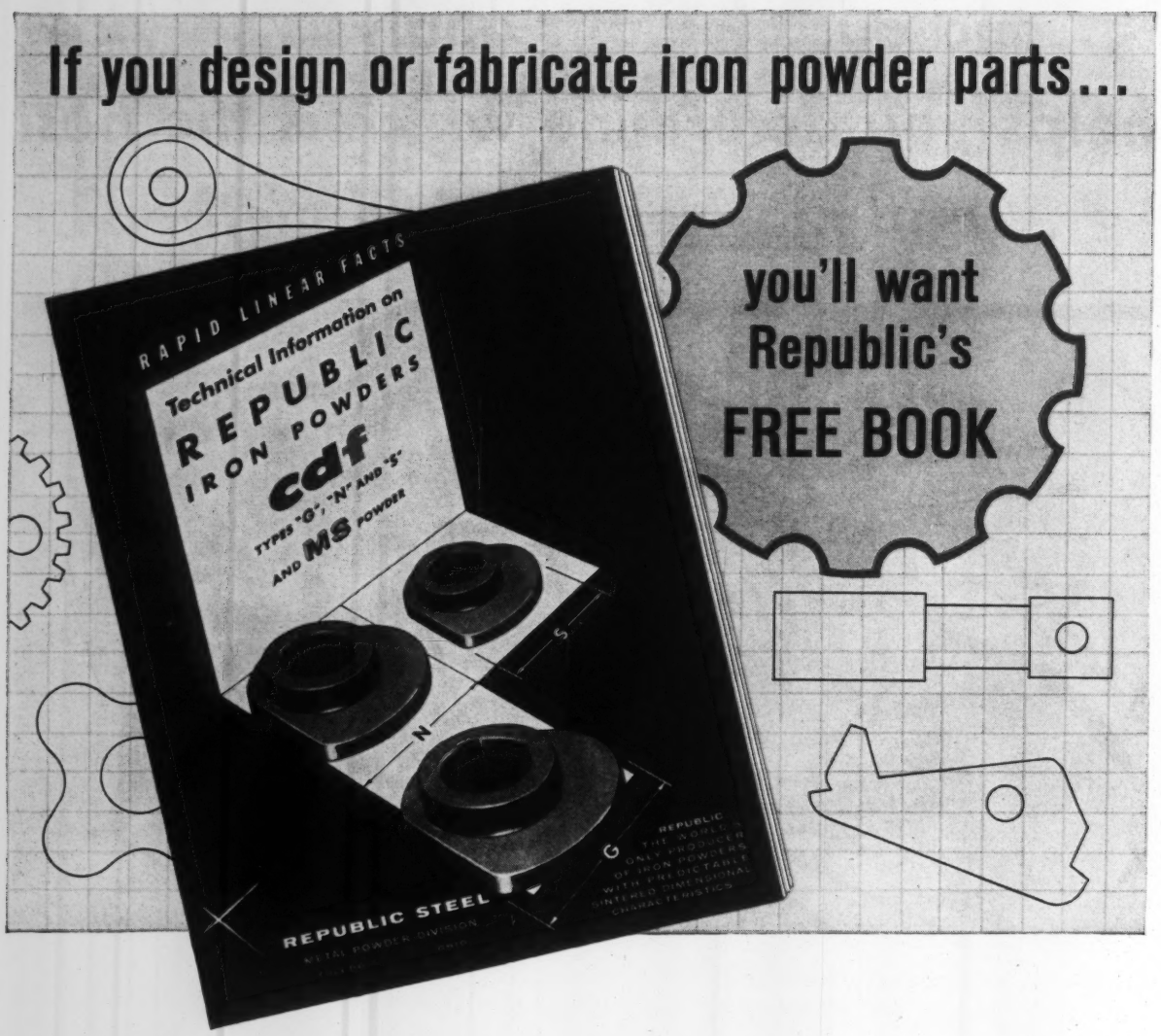
Since only Mueller Brass Co. can produce your part by all these methods, only the Man From Mueller Brass Co. can give sound advice on the one best method of production. Over 40 years of research, engineering, manufacturing and marketing experience stands behind him. When you are specifying and purchasing fabricated metal parts, call in the MAN FROM MUELLER BRASS CO.

271

PORT HURON 21, MICHIGAN

For more information, turn to Reader Service card, circle No. 452

If you design or fabricate iron powder parts...



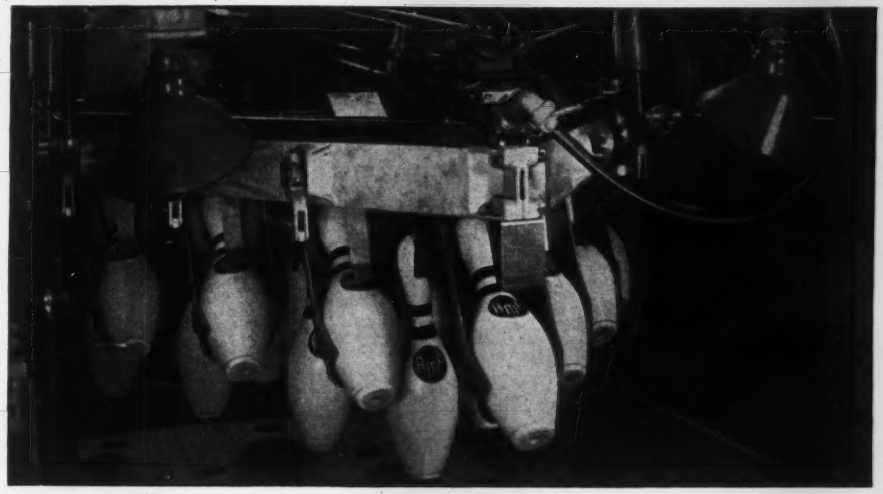
This new 48-page book has been prepared especially for tool engineers, part designers, metallurgists, and fabricators. It contains complete technical data on Republic's improved Controlled Dimensional Factor Powders and new MS Powder.

Data are presented by an entirely new method. Most of the necessary information regarding a particular powder's behavior can be read from the curves on a single set of ordinates.

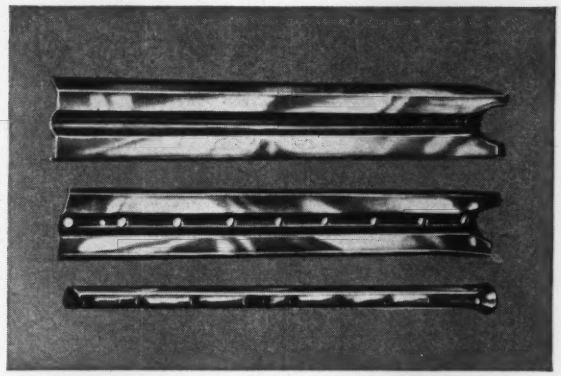
The first section of the book lists complete specifications for Republic's CDF Powders, Type "G" for growth, Type "N" for normal, Type "S" for shrinkage. Each of these powders has been improved with regard to compressibility, dimensional characteristics, and increased tensile strengths.

Section two provides complete information on Republic's new MS Powder, developed principally for use with graphite rather than copper. MS possesses features which make it economically attractive for use in a wide variety of mechanical parts, and in electrical and magnetic applications.

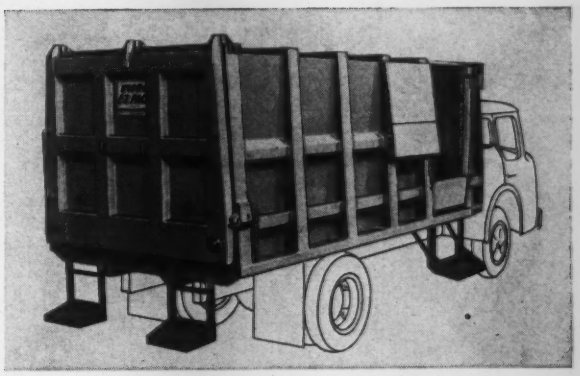
Mail the coupon for your free copy of Republic's new Iron Powder Book, ADV. 1014.



AMF CUTS COSTS, builds a better pinspotter with Republic ELECTRUNITE® Mechanical Tubing. On the initial order, ELECTRUNITE saved American Machine & Foundry Company, Brooklyn, New York, $34,000 in manufacturing their famous AMF Automatic Pinspotter. AMF was able to eliminate boring and grinding operations because ELECTRUNITE met O. D. tolerance requirements. This feature resulted in a savings of $15,000 in fabricating operations. Another $19,000 was saved on the cost of ELECTRUNITE as compared with tubing previously used. In uniformity, quality, original costs, Republic ELECTRUNITE Mechanical Tubing can save you time and money, too. Call Republic, or mail coupon for facts.



GREATER STRENGTH, CORROSION-RESISTANCE, and cost were prime factors in switching to stainless steel from brass in this automotive engine water distribution tube. Stainless was easily fabricated on existing tools. It took the constant flow of hot water and anti-freeze chemicals in stride. The greater strength of stainless virtually eliminated loss from bent or damaged tubes. Photo sequence shows fabricating operations: (1) Blank of .010" stainless strip after initial drawing and embossing, (2) Same blank after piercing of water outlet holes and trimming of flanges, (3) Completed tube after roll-forming and lock seaming. Mail coupon for more information on Republic ENDURO® Stainless Steel.



HIGH STRENGTH STEEL SOLVES WEIGHT PROBLEM in Hydro E-Z Pack enclosed truck bodies, manufactured by Hercules Galion Products, Inc., Galion, Ohio, for haulers of refuse and garbage. Tough, strong, lightweight Republic "50" High Strength Steel allows an E-Z Pack unit to be carried on a chassis as small as a two-ton truck. Reduced weight permits increased payload—fewer trips to the dump. High Strength Steel withstands the heavy compressive force of packer blades, allows tight compaction of loaded materials. High resistance to the corrosive and abrasive action of refuse assures long, dependable service. Write for full facts on Republic High Strength Steel.

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
Dept. ME -6865-B
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

☐ Send Iron Powder Book, ADV. 1014
Send more information on:
☐ Mechanical Tubing ☐ Stainless Steel
☐ High Strength Steel

Name _____ Title _____

Company _____

Address _____

City _____ Zone ____ State _____

For more information, turn to Reader Service card, circle No. 429

"WEIRKOTE'S® SOMETHING SPECIAL! IT CAN END THE NEED FOR ANY FURTHER CORROSION PROTECTION AFTER FABRICATION."

Q. You mean it? Weirkote can save you the cost of any further processing for corrosion protection after fabrication?

A. Absolutely. It's the continuous process that does it. Integrates the zinc to the steel so tightly there's never any peeling or flaking. No matter how severe the fabrication—any torture test you put it through—that bond stays put!

Q. Hmmm. Weirkote sounds great. One thing—is its zinc coating uniform throughout?

A. To the nth degree! Even the hardest-to-reach areas on the most complicated fabrications are completely protected.

Q. Corrosion-protected, you mean?

A. Corrosion-protected all over! So much so that you can work Weirkote to the very limits of the steel itself. So there you have it: stepped-up manufacturing efficiency, sharply curtailed manufacturing costs. All from Weirkote!

Send for free booklet that details the time-and-cost-saving advantages of skin-tight zinc-coated Weirkote. Just write Weirton Steel Company, Dept. E-1, Weirton, West Virginia.

WEIRTON STEEL COMPANY

WEIRTON STEEL COMPANY

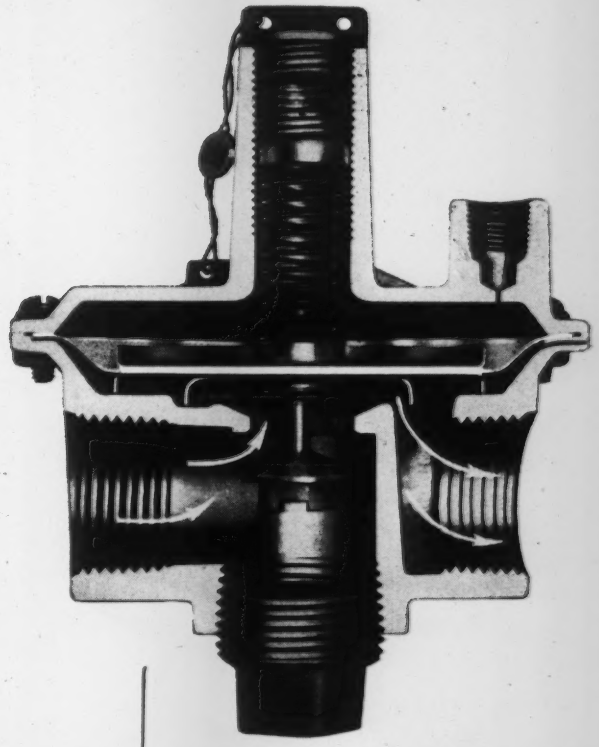
WEIRTON, WEST VIRGINIA

a division of

NATIONAL STEEL CORPORATION

For more information, turn to Reader Service card, circle No. 441

Small gas regulator delivers big capacity with supersensitive diaphragm of "FAIRPRENE"®



The regulator shown above would fit easily in the palm of your hand, yet has a capacity of up to 258 cu. ft. of gas per hour, with a pressure drop of only 0.5" of water. Thermac Company of Los Angeles, California, manufactures this regulator for gas appliances. The supersensitive diaphragm of "Fairprene"*-coated fabric helps this compact unit develop its exceptionally high capacity. And, because the "Fairprene" resists both aliphatic and aromatic hydrocarbons, the regulator can be used with all types of natural and manufactured gas.

Today Du Pont creates more than 70 "Fairprene" coated fabrics with many variations in chemical and physical properties. One would probably prove useful in your product or process. If you need a material resistant to gas, oils, solvents, corrosive chemicals or abrasion or flex cracking... a material that retains its properties at −100° F or 500° F... a material that possesses superior insulating or anti-stick properties, there's a Du Pont "Fairprene" coated fabric or sheet stock to do the job.

Du Pont engineers are eager to help you evaluate "Fairprene" for designing new products or improving existing ones. Mail the coupon or write E. I. du Pont de Nemours & Co. (Inc.), Fabrics Division DM 39, Wilmington 98, Delaware, for complete information.

COATING	FABRIC SUBSTRATES				
	COTTON	NYLON	"DACRON"*	GLASS	"TEFLON"*
NEOPRENE	●	●		●	
BUNA-N	●	●		●	
"FO"†	●	●			
BUTYL	●	●			
"HYPALON"*		●	●	●	
ACRYLIC			●	●	
SILICONE			●	●	●
"VITON"*			●	●	●

†A Du Pont name *Du Pont's registered trademark

At Du Pont special coatings are combined with selected fabrics to produce "Fairprene" which has the advantages of both. Tabulated above are many of the combinations possible. In addition, there can be many variations in the structural relationship between fabric and coating compound. Mail the coupon for more specific information on the variety of "Fairprene" materials available.

INDUSTRIAL COATED FABRICS
SHEET STOCKS · CEMENTS

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

E. I. du Pont de Nemours & Co. (Inc.)
Fabrics Division DM 39, Wilmington 98, Delaware

Please send—without obligation—complete information about Du Pont "Fairprene" coated fabrics. I am interested in using a

coated fabric for _____

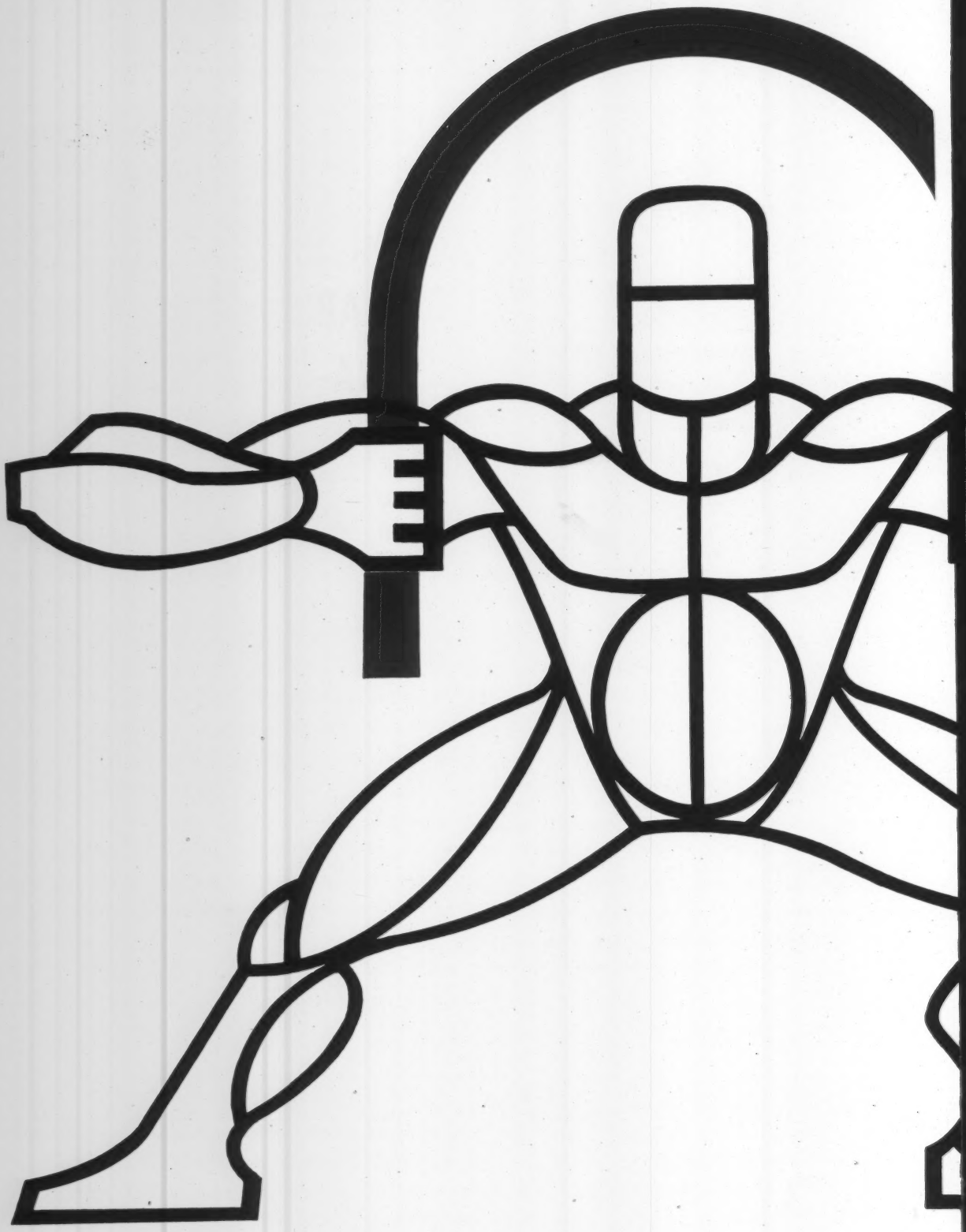
Name _____

Firm _____

Address _____

City _____ Zone _____ State _____

For more information, turn to Reader Service card, circle No. 367



NOW... SUPERIOR FORMABILITY IS AVAILABLE IN AN EXTRA-STRENGTH STEEL

N-A-XTRA

BEST LOW-ALLOY EXTRA-STRENGTH STEEL YOU CAN BUY

N-A-XTRA HIGH-STRENGTH is a heat-treated steel now available in minimum yield strengths of 80,000-110,000 psi.

Unlike most steels of this strength and toughness, N-A-XTRA can be cold formed into difficult shapes, gas-cut, sheared, machined, and otherwise handled by conventional fabricating methods. It has superb weldability—by any process. And its great strength gives designers and engineers a unique opportunity to eliminate useless dead weight from finished products.

For complete information on N-A-XTRA—the best low-alloy extra high-strength steel you can buy—write Great Lakes Steel Corporation, Detroit 29, Michigan, Dept. D-9.

N-A-XTRA

GREAT LAKES STEEL

A DIVISION OF NATIONAL STEEL CORPORATION

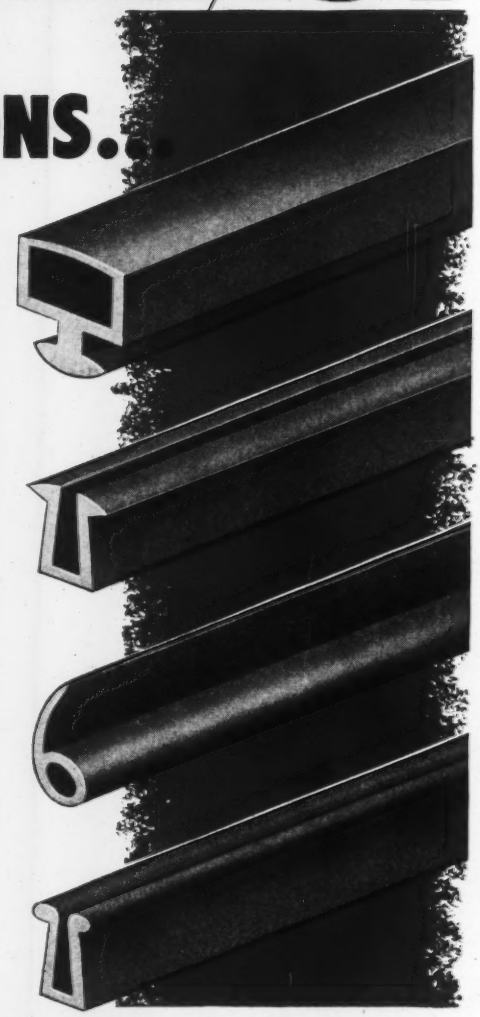
For more information, turn to Reader Service card, circle No. 426

IF YOUR PRODUCTS ARE IN ANY OF THESE STAGES

- IDEA
- DESIGN
- ENGINEERING
- ACTUAL PRODUCTION

You can *STILL* plan on using

CONNEAUT *Plastic* EXTRUSIONS...



If you have overlooked the many advantages of using plastic extrusions in your products, or put the idea aside believing that *standard* plastic compounds can't meet your design specifications, you'll be interested in the work we do here at Conneaut . . .

First, we formulate in our own laboratories scores of standard and special compounds from a wide range of plastic materials to obtain almost any range of properties required of plastics extrusions. Second, we have many standard dies suitable for use with these compounds, thus we may be able to produce your plastic extrusions without die cost. Third, if a special die is required we can produce it quickly and economically in our own die shop.

If your products are in any of the stages we've outlined . . . yes, even *actual production,* the Conneaut *custom* service on plastic compounding and extruding may be able to help you improve their quality and appearance, and lower manufacturing cost through easier fabrication.

Write today for complete, illustrated details. If you have an extrusion problem demanding immediate attention, send us your data and drawings. Our analysis and recommendations are prompt, and you are not obligated in any way.

137DR

THE CONNEAUT RUBBER AND PLASTICS COMPANY • CONNEAUT, OHIO

For more information, turn to Reader Service card, circle No. 508

For more information, circle No. 519 ➤

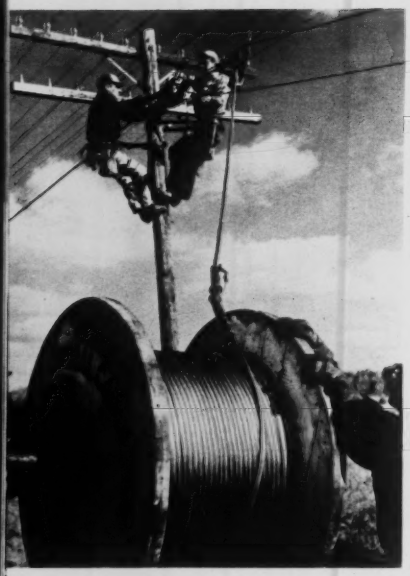
ASARCO

"the fast way out of today's profit squeeze is through the use of more efficient materials which cost less to work with, yet produce a better product..."

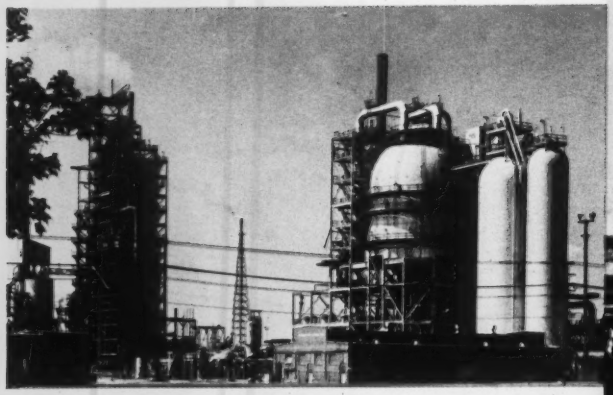
i.e. LEAD

SEE NEXT PAGE

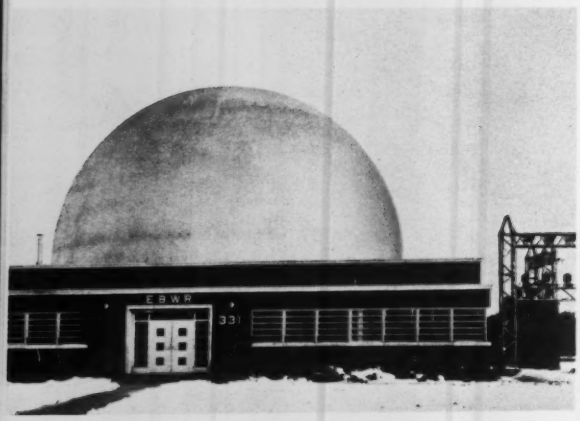
Asarco lead sheet and wool serve as protective barriers between reactors and personnel on America's great new atomic-powered submarines.



Trans-oceanic cable and other cable are sheathed with lead for unusually effective protection against corrosion.

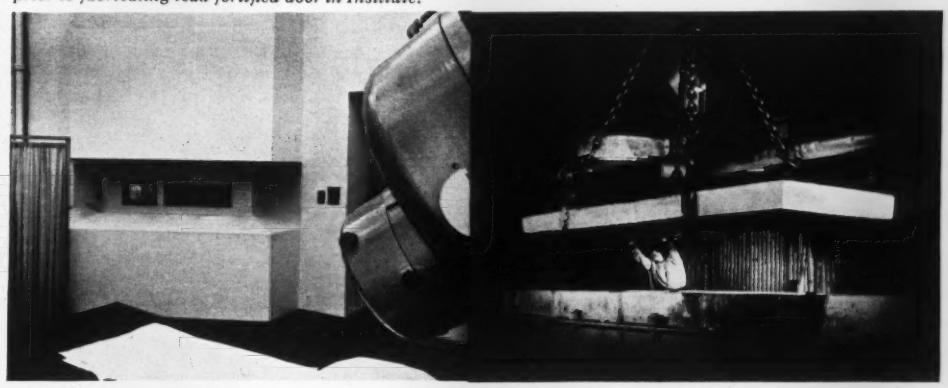


CHEMICAL PROCESSING: the high resistance of lead to weather, soil, many chemicals, particularly sulfuric, phosphoric, and chromic acids, makes it widely used for pipe, fittings, valves, heating and cooling coils, caulking, and drum and tank linings.



In the AEC Argonne National Laboratories, custom-shaped lead bricks, fabricated by Federated to precise specifications, provide maximum shield efficiency against gamma rays.

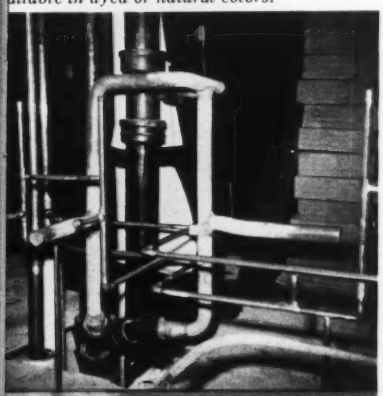
The 2-million volt Van de Graaf X-ray generator is housed in a room made safe from radiation by lead-fortified steel doors, lead brick, and lead-glass, 75% metallic lead by weight, through which observation and even photography is possible. (right) Handling lead slab prior to fabricating lead-fortified door in Institute.

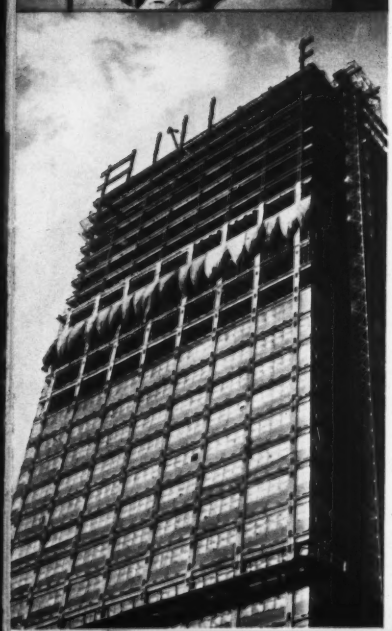


Refresh your memories of LEAD...

and rediscover that LEAD is remarkably, uniquely corrosion-resistant to weather, soil, salt water, acids and other chemicals... extremely durable, pliable, malleable... relatively inexpensive—salvable... and —now in the Atomic Age—the surest protection against radiation!*

w in cost, high in durability, lead plumbing tures, gutters, flashing, shower and safe ns are going into both large building d small home construction. (bottom) Aluminum nels on many new buildings are coated with ded-porcelain enamel, a 40% lead-coating ilable in dyed or natural colors.





"The wheel is come full circle . . ." Lead—one of the most ancient of metals—is today more widely used than ever.

The chemical processing industry uses its unique properties as a material resistant to the corrosive effects of strong acids. In building construction, lead's workability and durability are being put to use in plumbing, roofing and many other ways. Cable sheathed with lead has superior protection against moisture. Lead in brass, bronze, bearing, and steel alloys improves machineability.

Other important applications for lead include storage batteries, dies, electroplating, non-sparking floors, soldering, fusible alloys, lubrication, anti-knock ingredients in high octane fuel, and type metals.

But probably the most dramatic — and certainly the most vital use for the great density of lead today is as a protective shield against nuclear radiation.

Take a fresh look at lead — mined and refined by Asarco, the world's largest producer, and fabricated in Asarco's Federated Division.

**NOTE: Lead is salvable! A worn-out lead part pays toward its replacement. Old parts returned to Asarco are redeemed at full metal value (current market price less toll charges). Conceivably, a rise in the price of lead could mean that the salvage value of the old part matches the cost of the new replacement! LEAD PRODUCTS NEVER STOP PAYING FOR THEMSELVES!*

ASARCO

AMERICAN SMELTING AND REFINING COMPANY

From ASARCO, the world's largest processor of lead—

Lead products that never stop paying for themselves!

Asarco Sheet Lead
widths, lengths and thicknesses
Asarco Lead Pipe
Asarco Lead Fittings
Solid Lead Valves and Lead Lined Valves
Pig and Ingot
Lead Wool for caulking
Pellet Lead for alloying
Lead Bricks for radiation shielding
Asarco Lead Specialties
Solder
Type Metals
Babbitt Metals
Fusible Alloys

ASARCO lead refineries and Federated Metals Division plants are strategically located throughout the country to supply quality lead products.

Plants: Houston, Texas; Los Angeles and San Francisco, Calif.; Newark, Trenton and Perth Amboy, N. J.; Whiting, Ind. (Chicago)

ASARCO-Federated field engineers are on call from 23 sales offices, to back up Asarco lead products with experienced and extensive technical assistance.

Sales Offices:

Alton, Illinois
Baltimore 24, Maryland
Birmingham, Ala.
Boston 16, Mass.
Chicago, Ill. (Whiting)
Cincinnati, Ohio
Cleveland, Ohio
Dallas, Texas
Detroit 11, Michigan
El Paso, Texas
Houston 29, Texas
Los Angeles 23, Calif.
Milwaukee 10, Wis.
Minneapolis, Minn.
Newark 1, New Jersey
Philadelphia 7, Penna.
Pittsburgh 24, Penna.
Portland 9, Oregon
Rochester 4, New York
St. Louis, Missouri
Salt Lake City 1, Utah
San Francisco 24, Calif.
Seattle 4, Wash.

ASARCO maintains a great center of lead research in its Central Research Laboratory, South Plainfield, N. J., which has developed an encyclopedia of working knowledge about lead in all its applications. Write on your letter head for a free copy of one or more of these booklets: "Lead Handbook for the Chemical Processing Industry"; "Lead for Radiation Shielding"; "Lead Products for the Plumbing Industry," to American Smelting and Refining Company, 120 Broadway, New York 5, N. Y.

ASARCO

d'ARAZIEN

Alcoa puts the metal where you want it

More than a hundred tons of Douglas DC-8 kiss the runway on forged aluminum wheels like this one. Strength and lightness are obvious requirements. Even more essential is reliability through landing and after landing to guard the safety of passengers and crew.

Logically enough, rugged aluminum forgings were elected for the job. Then came many hours of Alcoa skill in die design, demonstrated in the remarkable zebra stripes visible in the cross section. They represent the aluminum grain flow* and illustrate how the tough aluminum grain is forged to withstand the shock loads of landing impact, plus the cyclic fatigue of rotation, all with a wide margin of safety.

Alcoa forges these wheels with a unique combination of blocker and finishing dies to put the metal exactly where it's needed. Alcoa Alloy 2014-T6 assures excellent machinability for the designer and producer, Bendix Products Division, Bendix Aviation Corporation. And Alcoa's forging plants, with hydraulic press capacities up to 50,000 tons, provide on-the-nose deliveries.

Think of Alcoa® Forgings when strength and lightness are rigid design requirements. Producing a complete line of forgings, Alcoa forges more large and complex shapes than any other supplier. Aluminum Company of America, 919 Alcoa Building, Pittsburgh 19, Pennsylvania.

**The patterns shown in the illustration were produced in Alcoa's Research Laboratories as part of a study of grain flow developed by the dies used to forge the DC-8 wheel.*

Alcoa puts the metal where you want it—in castings, forgings, impacts, extrusions and screw machine parts.

ALCOA ALUMINUM

For exciting drama watch "Alcoa Presents" every Tuesday, ABC-TV, and the Emmy Award winning "Alcoa Theatre" alternate Mondays, NBC-TV

Your Guide to the Best in Aluminum Value

ZIRCONIUM

costs less today than you may think!

A recently-published article in Metal Progress* provided an interesting economic appraisal of zirconium and stainless steel in nuclear power reactors. The article covered five power-producing thermal reactors spanning the entire range of fuel enrichment. To supplement these facts, we would like to add these key points about zirconium.

Check TODAY'S Zirconium prices

In our discussions with designers and builders of nuclear reactors, we still find some who think of zirconium prices in terms of $100 per pound. Actually, high quality zirconium strip and rod are available through Mallory-Sharon at *$11 to $14 per pound*. Even tubing—always more expensive in any metal—is frequently priced at under $30 per pound.

What is the break-even point?

In four of the reactors discussed in the article, the break-even price for fuel cladding material ranged from $44 to $104 per pound. On permanent parts, the range was from $109 to $842 per pound. Thus zirconium, at present prices, offers important economic advantages over stainless steel.

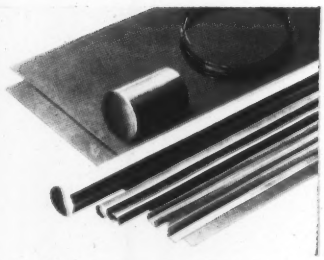
Future price trend important

The break-even point is not necessarily a static one. Future trends in prices of both zirconium and stainless steel must be taken into account.

For example:

1. As zirconium production and use increases, price of mill products will be reduced still further.
2. Increases in stainless steel prices will raise the break-even point.

Thus, for the future, certain applications which may be borderline cases at present, will most surely show definite economic advantages for zirconium.



Typical mill shapes produced in zirconium by Mallory-Sharon include rounds, bars, billets, wire, sheet, strip, plate, tubing.

Advantages of Zr for refueling

The declining price trend of zirconium has a vital bearing on cost of future refueling operations. Even where zirconium's present economic advantage may be close to the borderline, future price reductions will substantially increase this advantage 1½ to 2 years from now.

Use of natural uranium a key factor

Because of zirconium's low neutron-absorbing cross-section, uranium of lower enrichment may be employed. This further adds to zirconium's economic advantages through resulting savings in fuel costs.

For pricing assistance . . .

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TECHNICAL LITERATURE

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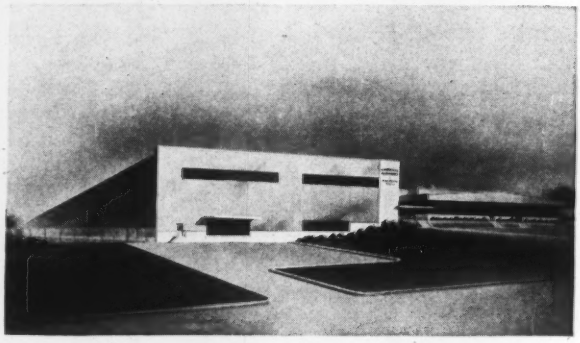
GOLD-CLAD STAINLESS TUBING CURBS CORROSION IN REACTOR

Photo pictures insertion of gold-clad stainless steel heat exchanger into gold-clad power reactor at AEC's Los Alamos Scientific Laboratory. Completely successful in recent operational tests, the unique reactor is designed to produce superheated steam in a single pass. This is the second experimental reactor using uranyl phosphate fuel—the first unit failed because of excessive corrosion in the heat exchanger. Gold-cladding now protects all structural parts in contact with the extremely corrosive solution.

Will clad metals solve *your* corrosion problems? Investigate the BISHOP line of clad metals. BISHOP was the first company to successfully produce gold-clad stainless tubing . . . coupon brings data. Use it.

NEW BISHOP TUBE MILL OPENS



Sketch shows new BISHOP facilities adjacent to the present tube mill in East Whiteland Township, west of Paoli, Penna.—completing the first stage in BISHOP's long range expansion program. This two-story structure will contain over 165,000 square feet of floor space. BISHOP platinum mechanical manufacturing operations also move to the East Whiteland plant.

BISHOP NOW DRAWING .002" WALL TANTALUM TUBING

Tantalum tubing with paper-thin wall thicknesses is now being supplied by BISHOP on special order. Sizes range from .062 in. OD x .002 in. wall to 1.5 in. OD x .125 in. wall. Columbium (niobium) tubing down to .002 in. wall has been produced and is also available. Can tubing of these "exotic" metals be the answer to any of your design problems? Check with BISHOP . . . use the coupon.

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platinum works

FOR HELPFUL DATA USE THIS HANDY COUPON

- ☐ Tubular Products Bulletin No. 12
- ☐ Platinum Products Catalog No. 4
- ☐ Clad Metal Data
- ☐ Special Tubing Data

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THIS IS THE BISHOP LINE:
Products of all the Platinum Metals... Small diameter Stainless Steel, nickel and special alloy tubing

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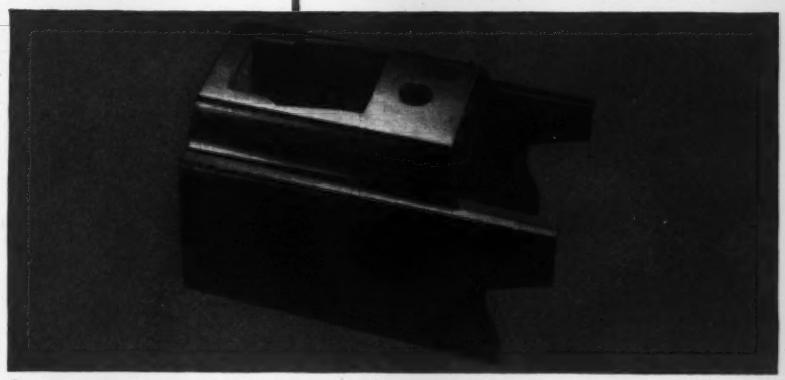
PROGRESS IN PLASTICS



Complex cover part made inexpensively from Dilecto grade XF—phenolic laminate with a kraft paper base.

POSTFORMING—THE INEXPENSIVE WAY TO MAKE COMPLICATED PARTS

How it's done. Briefly, postforming is effected by heating Dilecto stock until it is pliable, then placing it in an unheated, inexpensive mold, and pressing until the laminate cools enough to retain its shape.

Less expensive. Postforming is less expensive than other molding methods, because, generally, lower-cost dies and tools can be used. Frequently, dies can be constructed of wood or plastics rather than of tool steel. Also, retooling to meet new specifications is cheaper. Dies are more adaptable. Labor costs are reduced.

Why Dilecto? Dilecto plastics laminates are excellent for postforming applications where the following qualities are required: high strength-weight ratios, superior electrical and chemical properties, and resistance to abrasion, weathering, moisture, and corrosion. Light weight is another major Dilecto asset.

Special Dilecto grades. Special Dilecto postforming grades respond to sharper bends and deeper draws, and take more complex contours without fracturing. However, most grades of Dilecto can be postformed to a limited extent. CDF Technical Bulletins 21 and 46 describe postforming grades in detail.

CDF silicone-rubber tapes insulate Electro-Flex heaters

Bread on the "sandwich". Construction of Electro-Flex heaters consists of a vulcanized "sandwich" of silicone-rubber tape on both sides of patterns of resistance wire. Standard Electro-Flex heaters consist of four plies of CDF silicone-rubber tape (woven glass-fiber cloth with silicone-rubber calendered on). Each ply is .010-in. thick. For extreme flexibility, this CDF customer makes a Hi-Flex (trade name) heater.

Heat up missiles and rockets. Electro-Flex heaters are on all U.S. missiles and rockets. Typical are the Atlas, Thor, and Redstone, where they heat pipes and valves in the fuel system. Industrial applications include storage-drum heaters, heat sealing, and oven heaters — particularly small crystal ovens. CDF supplies 80% of the silicone-rubber tapes used by Electro-Flex. Request Bulletin SR-3.

Flexible Teflon-impregnated glass cloth

Combines advantages. Flexible new Dilecto GB108TED combines the high tensile strength and resistance to flow typical of glass-cloth laminates with the low permeability, excellent chemical resistance, and superior electrical properties of DuPont Teflon TFE fluorocarbon resin. It consists of glass cloth impregnated and covered on both sides with a continuous film of Teflon resin. An important advantage: freedom from pinholes.

Where it's used. Dilecto GB108TED is suitable for corrosion-resistant parts like gaskets and seals. Also for electrical insulation like radar windows, flexible printed circuits, and tape cable. It shows unusually high tear-resistance, and can be formed into simple shapes. Request Bulletin GST-58A.

Dilecto GB108TED is offered as continuous, natural-color, smooth-finish sheet in coils. Maximum width 6". Maximum length 75'.

NEW CDF LITERATURE • *Bulletins referred to in this advertisement may be obtained from your CDF representative, or you may send the coupon below, indicating the Bulletins you want.*

Please send me the following Technical Bulletin(s);

- ☐ Bulletins 21 and 46 — CDF Postforming Grades
- ☐ Bulletin GST-58A — CDF Teflon-impregnated glass cloth
- ☐ Bulletin SR-3 — CDF Silicone-Rubber tape

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URETHANE FOAM...
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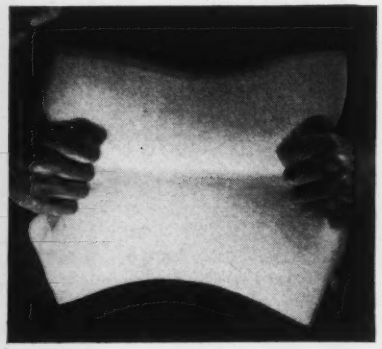
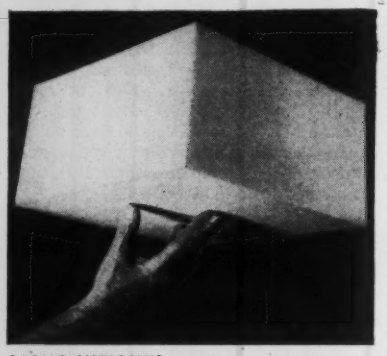
TOUGH! Tear strength up to 8 psi; tensile strength up to 40 psi; may be stretched to 500% of original length without parting.



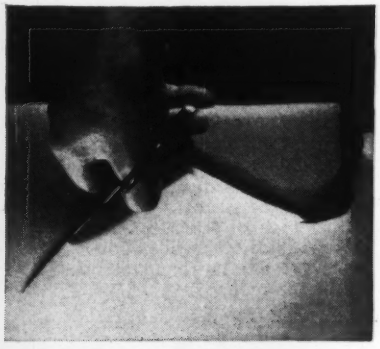
STRONG! Urethane foams have been flexed at 30 cps at 30-80% deflection for 3,000,000 cycles with minimum property loss.

CHEMICALLY STABLE! Urethane foams are unharmed by dilute acids, alkalies, detergents, water or dry cleaning solvents.



LIGHT WEIGHT! At 2 lbs. pcf, properties of urethane foams are superior to other foams weighing twice as much.

SOFT! An entirely new experience in cushioning effect. You will have to *feel* urethane foams to understand the growing preference for these materials in cushioning markets.



VERSATILE! Urethane foams may be sliced, sawed, sewn, stapled, glued, sprayed or foamed in place, die-cut, flocked, laminated, tufted, contour-cut, with standard fabricating equipment.

Here's a versatile engineering material that will enable you to convert designer's dreams into manufacturing realities with a minimum of time, cost or experimentation.

If you have a design or engineering problem requiring a highly functional material for cushioning, insulating, void filling or padding, urethane foam might be the answer.

Write Mobay for detailed technical information and sources of supply.

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Mobay is the leading supplier of quality chemicals used in the manufacture of both polyether and polyesterurethanefoams.

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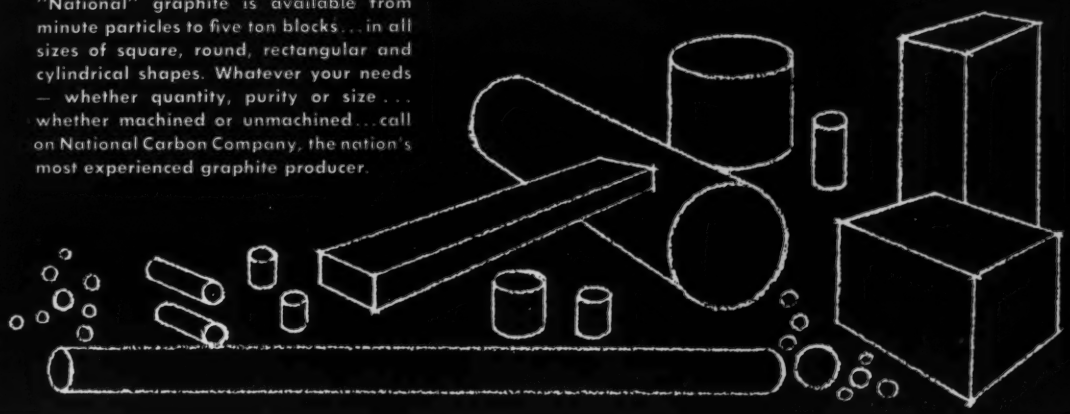
TRADE-MARK

...it has a unique combination of properties

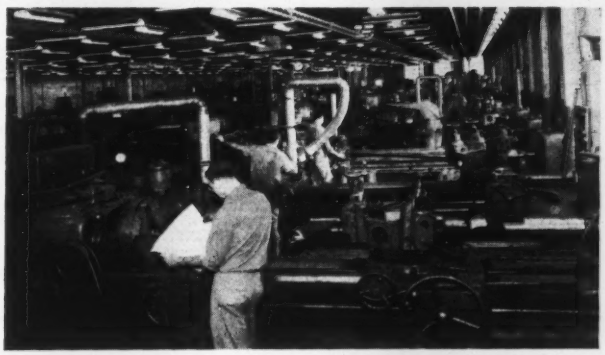
RESISTS THERMAL SHOCK	**GOOD ELECTRICAL CONDUCTIVITY**	**CORROSION RESISTANCE**	**STRENGTH INCREASES WITH TEMPERATURE RISE**
HIGH THERMAL CONDUCTIVITY	**LOW THERMAL EXPANSION**	**NOT WET BY MOST MOLTEN METALS**	**EASY TO FABRICATE**

...it's available in a wide variety of sizes and shapes

"National" graphite is available from minute particles to five ton blocks... in all sizes of square, round, rectangular and cylindrical shapes. Whatever your needs — whether quantity, purity or size... whether machined or unmachined... call on National Carbon Company, the nation's most experienced graphite producer.



...and NATIONAL CARBON can machine it to your specifications



One of several well equipped NATIONAL CARBON machine shops for fabricating graphite.

Economically machining graphite at National Carbon Company is a result of years of graphite machining experience teamed with modern equipment located at several strategic locations. Turning out simple or intricate shapes and holding to close tolerances are everyday procedures at these shops. No job is too small or too big, too simple or too complex to receive the required expert consideration and attention.

Whatever your needs, whether simple or complicated parts made from standard or special grades, let National Carbon Company quote on your requirements. For details, contact your National Carbon representative or the nearest sales office.

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Spaulding FIBRE FACTS FOR ENGINEERS NUMBER 1

The Unique Deionizing and Non-Arc Tracking Properties of Vulcanized Fibre and Their Applications

by Earl A. Russell, Chief Engineer, Spaulding Fibre Company, Inc.

• When subjected to high temperatures such as those created by an electric arc, Spaulding Vulcanized Fibre produces an arc-quenching gas. Two important effects are noted:

1. The Fibre neutralizes the charges present in the air that has been ionized by the arc, permitting instant reassociation or deionizing. Ionized air conducts electricity. Deionizing it re-establishes air's normal insulating characteristics, thus extinguishing the arc and preventing the line current from flowing through to ground.

2. The Fibre covers itself with a gaseous, non-flammable layer that suppresses combustion of the fibre. This effect resists the formation of a carbon track between electrodes when an electric arc passes over the surface.

All grades of Spaulding Vulcanized Fibre have these properties. However, the greater density of Spaulding Supergrey (Bone Grade) provides them to a superior degree.

Applications

In addition to the applications noted in Figures 1 and 2, Spaulding Vulcanized Fibre is especially suited for these uses:

• Fibre properties which cause it to be non-arc-tracking and arc extinguishing, lead it also to resist igniting under short term, high temperature arcs such as might be encountered in the burning of a fuse link or when used as an arc shield.

• Fuse cases of solid wall fibre tubing for inside fuses and as an inner liner in Spauldite tube cases for pole line outdoor fuses exposed to weather. This takes advantage of the structural strength of Vulcanized Fibre tube in addition to the resistance to igniting characteristics.

• Both oil switches and oil circuit breakers designed to interrupt high power currents take advantage of the arc extinguishing properties of Vulcanized Fibre by drawing the arc through narrow and circuitous channels in the fibre baffle stacks.

• Perhaps the most spectacular use made of the deionizing properties of Vulcanized Fibre is in the lightning surge arrester units of the expulsion type. These are now available in many types, all based upon the principle of conducting the lightning discharge to ground through an external and internal gap. In the latter, the arc chamber provides small passageways in the Vulcanized Fibre designed to extinguish the arc in microseconds to prevent power current from following through to ground.

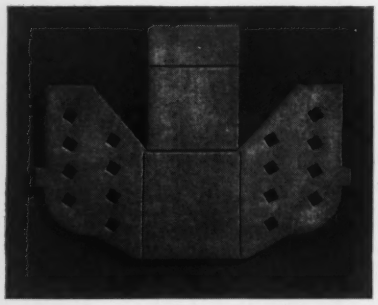


FIGURE 1. The arc extinguishing properties of Spaulding Vulcanized Fibre are used in distribution switches and small circuit breakers where opened contacts draw the arc close to the fibre surface where it is extinguished.

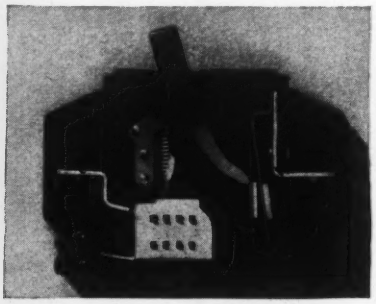


FIGURE 2. In the widely used circuit breaker, a combination of metal grids held within a framework of Spaulding Supergrey Fibre is economical and effective in snuffing the arc. Serving the same purpose as a fuse it has the advantage of quick re-use after cutting the circuit.

SPAULDING VULCANIZED FIBRE SHEETS *PHYSICAL PROPERTIES*

PROPERTY	THICKNESS INCHES	COMMERCIAL GRADE For Mechanical and Electrical Use		BONE GRADE SPAULDING SUPER GREY Highest Density Maximum Hardness	
Tensile Strength P.S.I. Typical	1/8 to 1/2 incl.	Crosswise 7,500	Lengthwise 12,000	Crosswise 7,500	Lengthwise 12,500
Flexural Strength P.S.I. Min.	1/8 to 1/2 incl.	Crosswise 12,000	Lengthwise 14,000	Crosswise 13,000	Lengthwise 15,000
Izod Impact — Ft/lbs per in. of Notch, Min.		1.2	1.6	1.0	1.4
Density — G. per Cu. Cm. Min.	Over 3/32 to 5/8 incl.	1.20		1.30	
Water Absorption Change in Wt. % Max.	1/8	2 Hr. 35	24 Hr. 61	2 Hr. 20	24 Hr. 48
Dielectric Strength Volts per Mil. Min.	Over 1/8 to 3/8 incl.	100		100	

Low heat conductivity oil, grease and solvent resistant, light weight, tough, resilient, high mechanical and electrical properties, easily machined and formed, wear resistant, economical.

Write for a free copy of Spaulding's new booklet, "Vulcanized Fibre Engineering Data"

SPAULDING FIBRE COMPANY, INC.

319 Wheeler Street Tonawanda, New York

For more information, turn to Reader Service card, circle No. 380

Photo courtesy Radio Corporation of America

Secret of a Smashing Success

Dropped 10 feet—this polystyrene radio case bounced, clattered, *but did not break*. It did not chip or crack—did not show a single mark of its high dive. Dramatic evidence, wouldn't you say, of the remarkable strength being built into modern plastics.

How to make tougher polystyrene—the material used in most radio cases—was long a priority project with all its manufacturers. Concentrated research and development finally solved the problem. The secret of success for many producers: combining the product with PLIOFLEX rubber.

Plioflex, with its unusually light color, high uniformity and particular physical properties, was selected over many other possible modifying materials. Experience has proved it to be the best choice to meet the exacting demands of the plastics industry.

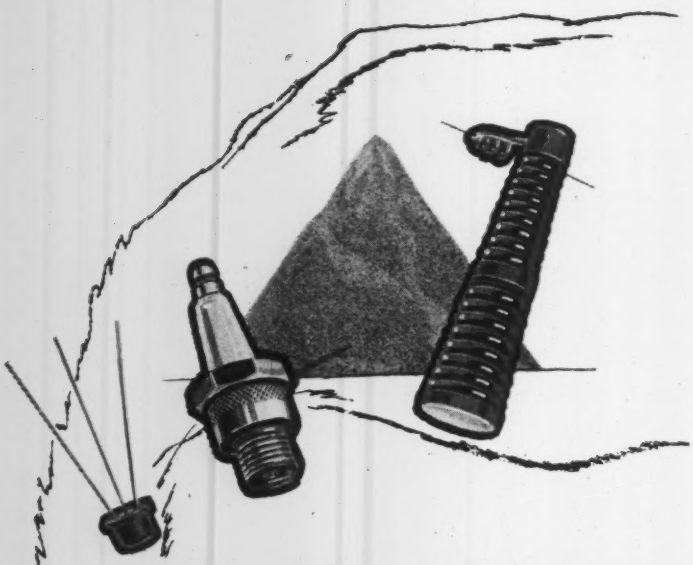
Making more durable, more salable radio cases is but one of the many uses for the many types of PLIOFLEX. How can PLIOFLEX bring new success to your operation? For full details—including latest *Tech Book Bulletins*—write Goodyear, Chemical Division, Dept. I-9437, Akron 16, Ohio.

GOODYEAR

CHEMICAL DIVISION

Plioflex—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

For more information, turn to Reader Service card, circle No. 412



Here are the "basic ingredients" in some of today's most advanced design concepts . . . Norton Ceramic Materials. Exceptionally versatile, these exciting materials are meeting operating requirements of products and processes across industry.

Norton Ceramic Materials offer design engineers a wide range of outstanding physical, chemical, thermal, and electrical properties. What's more, they provide interesting *combinations* of these properties. For example: CRYSTOLON* silicon carbide provides high thermal conductivity as well as exceptional thermal strength; ALUNDUM* aluminum oxide has excellent chemical stability in addition to good abrasion resistance; MAGNORITE* magnesium oxide offers high purity, thermal and electrical resistance; fused

Dynamic Ideas in Engineering . . .

thrive on Norton ceramic materials

zirconium oxide is today's highest melting point material available in tonnage quantities and it's immune to both reducing and oxidizing atmospheres. And each product has *many* other invaluable properties.

Think of Norton Ceramic Compositions as essential components in equipment for metal and chemical processing, electrical, electronic, ceramic and nuclear applications . . . as "the answer" to literally hundreds of design problems. They're manufactured to meet highly exacting standards of purity, density, shape, size and wear resistance . . . available in granular and in fabricated form to meet *your* requirements efficiently and economically. For complete details, write for "Norton REFRACTORY GRAIN". NORTON COMPANY, Refractories Division, 348 New Bond Street, Worcester 6, Mass.

*Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries

NORTON
REFRACTORIES
Engineered . . . Rx . . . Prescribed

Making better products . . . to make your products better

NORTON PRODUCTS Abrasives • Grinding Wheels • Grinding Machines • Refractories • Electrochemicals — **BEHR-MANNING DIVISION** Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

For more information, turn to Reader Service card, circle No. 396

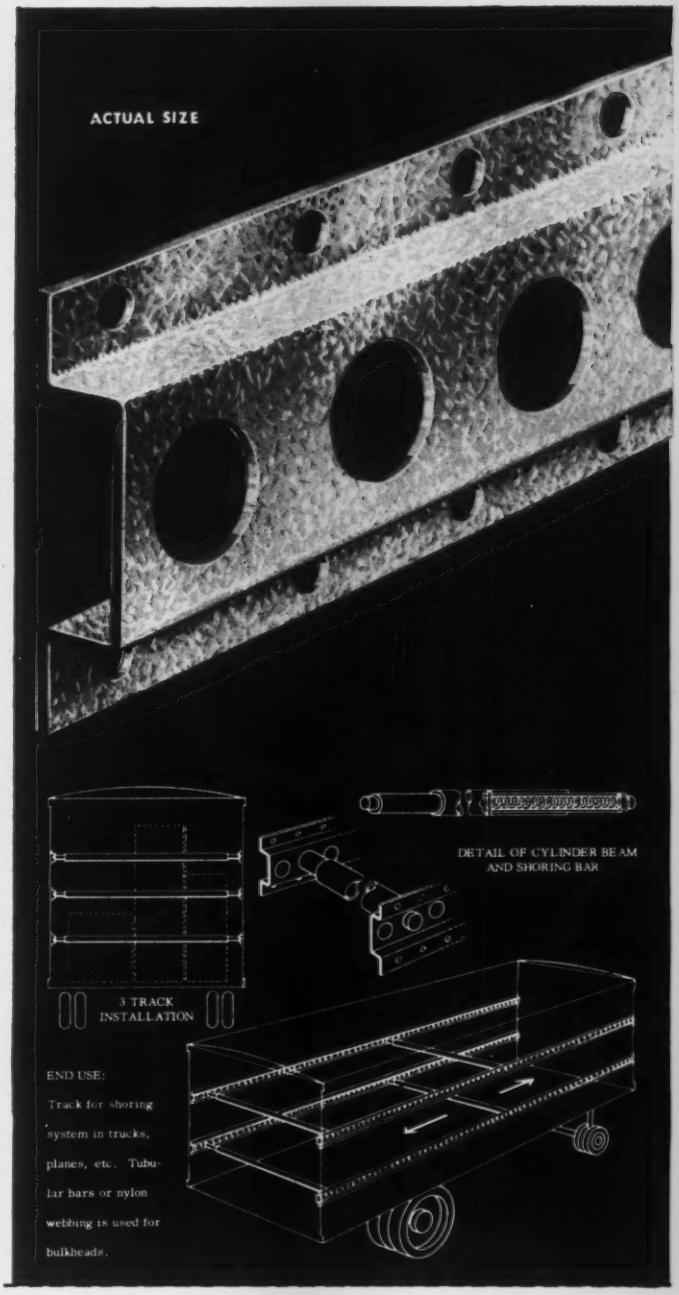
SHAPE OF THE MONTH

Aeroquip

CARGO CONTROL SYSTEM TRACK
BY

VAN HUFFEL

Where ideas VH *take shape*


ACTUAL SIZE
DETAIL OF CYLINDER BEAM AND SHORING BAR
3 TRACK INSTALLATION
END USE:
Track for shoring system in trucks, planes, etc. Tubular bars or nylon webbing is used for bulkheads.

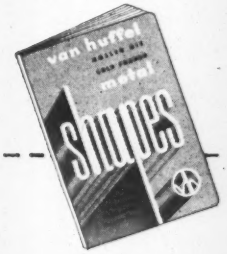
This track for shoring system in trucks, planes, etc. was produced for Aeroquip Corporation and is just one of many ideas Van Huffel roller die, cold forms in metal for a wide variety of industries. Your requirements may call for a more complicated shape. If so, you will be interested in these advantages of Van Huffel cold formed metal shapes: (1) Any of the common metals—hot or cold rolled steel, stainless steel, high strength steels, coated steels, aluminum, copper, brass—as well as painted or plated metals or bimetal sections can be formed in any lengths. (2) Structural sections have a high strength-to-weight ratio. (3) Parts can be fluted, seamed, notched, beveled, welded, punched, coiled, curved and embossed. (4) The finish of the stock is not marred. (5) Sections can be formed from metal strip 33" wide of uniform thickness up to a maximum of .312 gauge and a minimum of .003 gauge.

If you make it of metal . . .

Mail the coupon for your free

METAL SHAPES HANDBOOK

48 pages of information on material selection, fabrication methods, tolerances for roll forming and dozens of illustrated ideas that have taken shape in metal.



VAN HUFFEL

TUBE CORPORATION • WARREN, OHIO

Name_____ Title _____

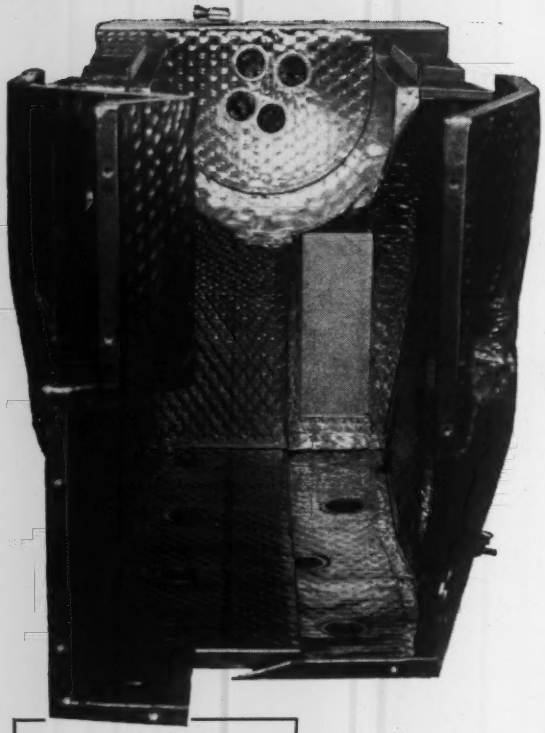
Company_____

Address_____

City_____ Zone____ State_____

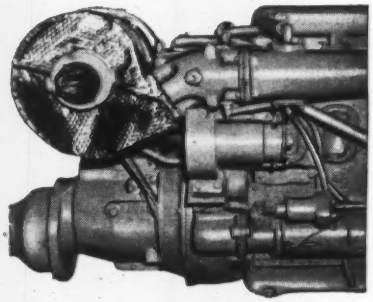
For more information, turn to Reader Service card, circle No. 501

Johns-Manville PRE-KLAD insulations are made possible through the company's extensive experience in fabrication and forming of thin foils.



This typical PRE-KLAD insulated housing features combination of molded parts, strengthened channel construction, close tolerance cut-outs to accommodate fittings and attachments.

Now—insulate difficult shapes in one fast operation . . .



PRE-KLAD as used by diesel engine manufacturers. Here, J-M engineers worked with customer's engineers to develop insulated blankets that readily slip over turbochargers to protect personnel and keep engine room temperature down.

Among the many PRE-KLAD applications

- Gasoline Engines
- Gas Turbine Engines
- Steam Turbines
- Heated Mechanical Equipment
- Domestic and Industrial Furnaces
- Stress Relieving Blankets
- Ingot Pads
- Heated Laboratory Equipment
- Diesel Engines, Manifolds, Turbochargers
- Home Incinerators, and other Hot Appliances
- Portable Heat Retention Equipment
- Turbogenerators
- Materials Handling Equipment
- Gear Housings
- Removable Casting and Forging Covers
- Furnace Nozzle Cones

with Johns-Manville PRE-KLAD Insulation!

New refractory fiber insulation is factory sheathed in heat-resistant foils to any required shape . . . temperatures to 2000F!

In new PRE-KLAD insulation, designers have an insulation that's right in step with efficient assembly line methods. For PRE-KLAD components arrive at your plant ready to install . . .. in one fast operation!

Originally developed for jet aircraft . . . PRE-KLAD insulations are precision engineered to solve individual heat retention problems. Johns-Manville tool engineers create the special molds and dies to form the stainless steel or other thin foils into the shape you require. Then, refractory felt insulation is expertly sandwiched between inner and outer foil jackets, which are then spot- or seam-welded into a ready-to-install housing or blanket. The result is an insulating component that can be used wherever a strong, lightweight foil-protected insulation is indicated.

The insulation in PRE-KLAD is Johns-Manville CERAFELT® . . . a refractory fiber insulation that is produced by converting molten refractory materials into a mass of uniform ceramic fibers. The fine CERAFELT fibers are then felted with a minimum of binder to form an insulating material that combines lightness, heat resistance and an extremely low *k* factor.

Write today for the informative new brochure on PRE-KLAD insulations.
Address Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ont.

JOHNS-MANVILLE

JOHNS-MANVILLE JM PRODUCTS

For more information, turn to Reader Service card, circle No. 403

At arctic temperatures and supersonic speeds

...what happens to aircraft skin?

Technicians of Aircraft X-ray Labs, Huntington Park, Calif., radiograph fin of aircraft at -65°F

WITH AIRCRAFT POWER mounting, with speeds that leave sound behind, extremely high frequency vibrations were bound to build up. What would be their effect on aircraft structures—at temperatures ranging to 65°F below zero? To find out, radiography and Kodak Industrial X-ray Film, Type AA, were put to work.

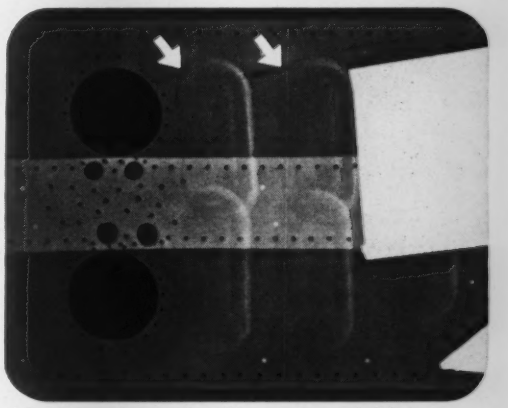
The radiographs revealed fatigue failures and gave clues to the nature of the stresses.

Exposures were made at target distances from 5′ to 15′ with exposures from 40 sec. to 90 sec. In spite of the cold, the film received no special handling.

All of which shows the importance of radiography as a test—also the dependability and versatility of Type AA Film.

If you build intricate assemblies, make castings or produce welded products, radiography can provide inside information as nothing else can. It can save time and money—improve foundry production and welding operations.

If you would like to know how it can help you, discuss it with your Kodak x-ray dealer—or with the Kodak Technical representative.



Radiograph reveals evidence of material fatigue under stress.

X-ray Division . . . EASTMAN KODAK COMPANY. . . Rochester 4, N. Y.

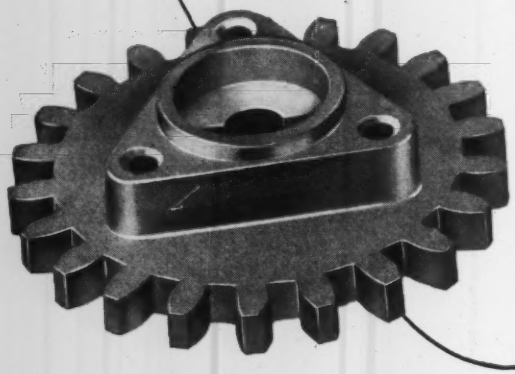
Read what Kodak Industrial X-ray Film, Type AA, does for you:

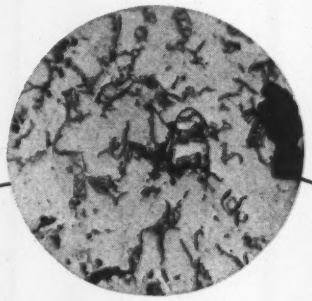
- Speeds up radiographic examinations.
- Gives high subject contrast, increased detail and easy readability at all energy ranges.
- Provides excellent uniformity.
- Reduces the possibility of pressure desensitization under shop conditions.

Kodak

For more information, turn to Reader Service card, circle No. 368

Quality of GRAMIX® precision parts insured by metallurgical control in the laboratory *proven by performance on the job!*





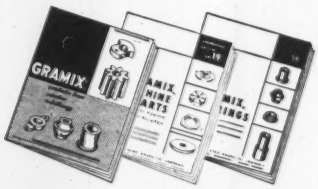
Photomicrograph of a section of an inferior powder metallurgy part that has been improperly sintered. Structure is composed of cementite and ferrite.

Photomicrograph of an internally sound GRAMIX part shows the fine grain structure of tough, shock-resistant pearlite.

To assure the dependable performance of GRAMIX powder metallurgy parts in actual operation, the United States Graphite Company combines exacting laboratory tests and rigid production controls to insure the quality of every GRAMIX part. Through the use of the metallograph, for example, GRAMIX engineers can check the internal structure of a part. A comparison of the photomicrographs shown above readily shows the sound under-the-surface quality of a GRAMIX part as opposed to the poor internal composition of an improperly sintered part. In the photomicrograph at the top, notice the cementite between the ferrite grain boundaries. This cementite will tend to break up and rupture under shock. The surface of the material is decarburized and only remnants of pearlite remain. *This condition is due entirely to the lack of adequate sintering control!*

The photomicrograph of the GRAMIX part at the bottom shows a fine grain pearlite structure that's tough, strong and wear resisting. Absolute sintering control along with precise metallurgical control in the laboratory is utilized by The United States Graphite Company to positively assure quality GRAMIX parts.

Write today for these helpful engineering manuals. Engineering Bulletin No. 18 covers design and metallurgical requirements and alloy selection of GRAMIX bearings. No. 19 contains facts about GRAMIX Machine Parts and No. 21 contains general information on GRAMIX products from Powder Metallurgy. Get your copies now.



X-264-1R

THE UNITED STATES GRAPHITE COMPANY

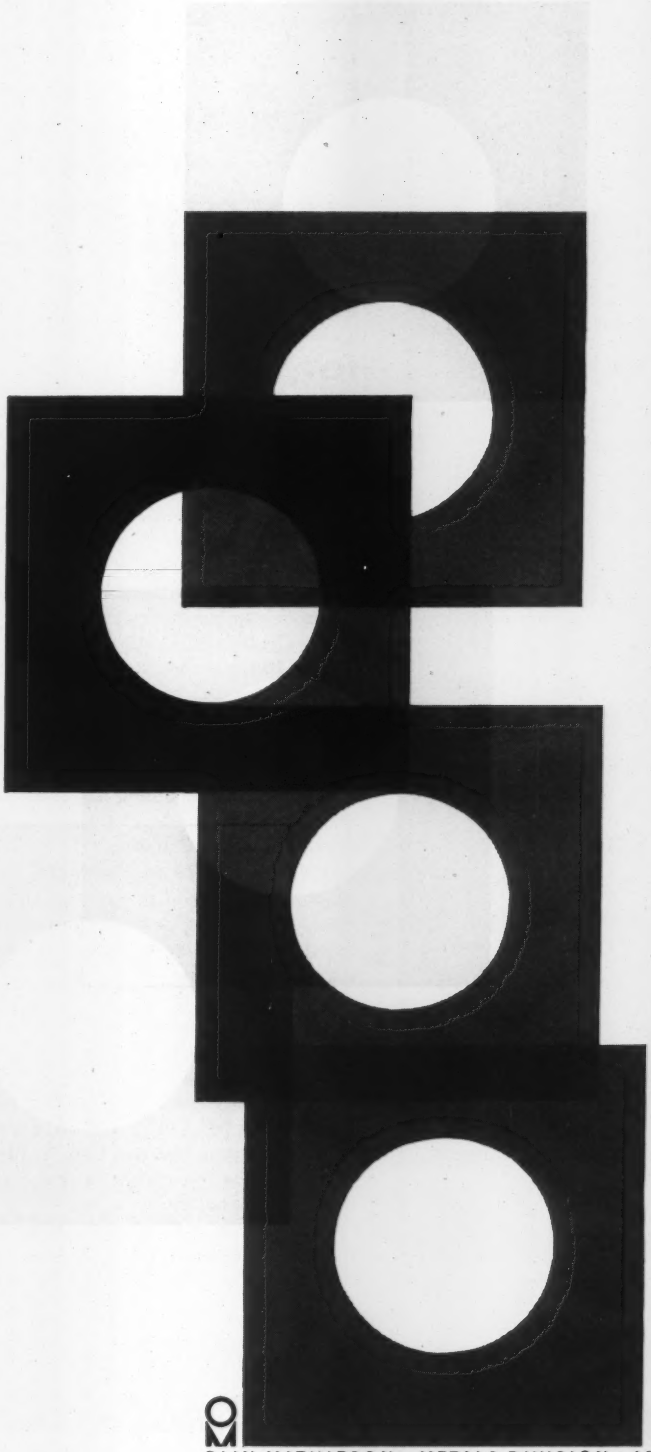
DIVISION OF THE WICKES CORPORATION, SAGINAW 3, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

For more information, turn to Reader Service card, circle No. 447

"Heads-up thinking by my Olin Aluminum Representative gave me

A Better Fin Stock Alloy . . . for less money"



"Here's how I found out about a more efficient fin stock alloy that actually saved me one per cent on my materials cost," says Lester Ramberg, General Manager of Ramco Manufacturing and Engineering, Portland, Oregon. "My other suppliers had been recommending 3003-H14. But the man from Olin Aluminum suggested 5005-H34—which yields more parts per truckload. And he was right. With 26% better thermal conductivity, the 5005-H34 proved a much better alloy for the job."

* * *

You too, can count on heads-up thinking by the man from Olin Aluminum. What's more, his keen insight into your problems is augmented by the Olin Aluminum Technical Advisory Service. Feel free to regard them as your personal storehouse of profit building ideas for using aluminum.

HERE'S WHY 5005-H34 WAS BETTER FOR MR. RAMBERG'S FIN STOCK

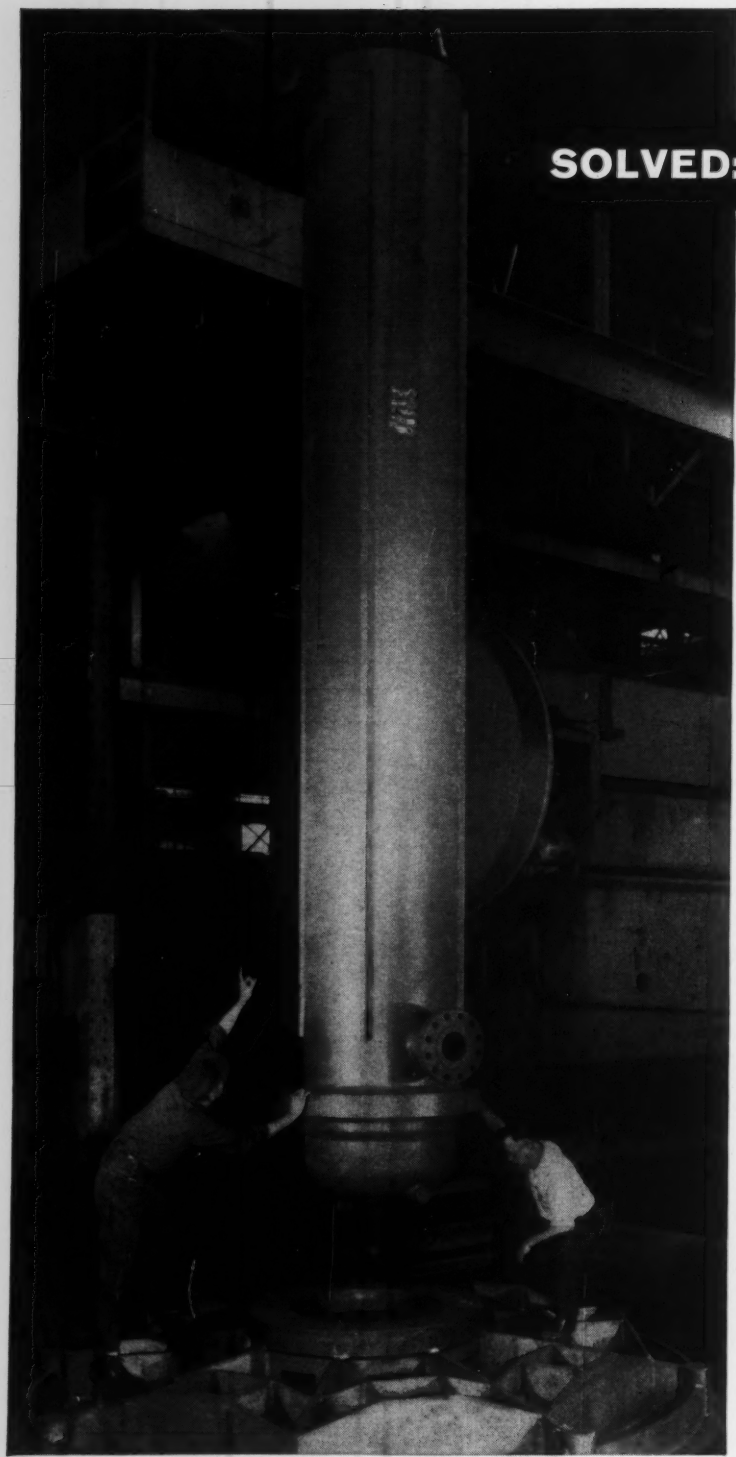
	density	thermal conductivity
3003-H14	.099 #/cu. in.	1100 B.T.U.
5005-H34	.098 #/cu. in.	1390 B.T.U.

The 1 per cent density saving gives a 1 per cent material saving. The higher thermal conductivity of 5005 gives a 26% increase over 3003. Fewer or smaller fins can do the same heat-exchanging job.

OLIN ALUMINUM®

OLIN MATHIESON • METALS DIVISION • 400 PARK AVENUE • NEW YORK 22, N. Y.

For more information, turn to Reader Service card, circle No. 523



Blaw-Knox workmen assembling one of two constant pressure type accumulators built for two of America's largest steel mills. Sandusky supplied the straight cylindrical sections for both.

SOLVED: by Sandusky Centrifugal Casting

Blaw-Knox chooses 10-ton

SANDUSKY CASTING

for giant slabbing mill

When an 18½-foot cylinder was needed for a new giant Universal slabbing mill built by Blaw-Knox Company's East Chicago (Indiana) Works for a well known steel mill, they found that the most practical and economical way to meet all requirements was with a Sandusky Centrifugal Casting.

This 10-ton carbon steel cylinder, 32" O.D. with a 3½" wall, functions as an accumulator in the mill's hydraulic roll balancing system. Essentially a pressure vessel, it simultaneously supports the ram and ballast weighing 226 tons—the weight required to develop constant operating pressure of 1000 p.s.i.

"Only a dimensionally stable, one-piece cylinder could perform satisfactorily in this service," a Blaw-Knox official asserted. *"Distortion could lead to binding, loss of pressure and costly downtime. Sandusky's ability to produce this heavy walled cylinder in one 18½ foot length met all our requirements of cost, stability, and strength."*

Sandusky cylinders up to 33 feet long —from 7" to 54" O.D.— and in a wide range of ferrous and non-ferrous alloys —may well be the answer to *your cylindrical problems,* too.

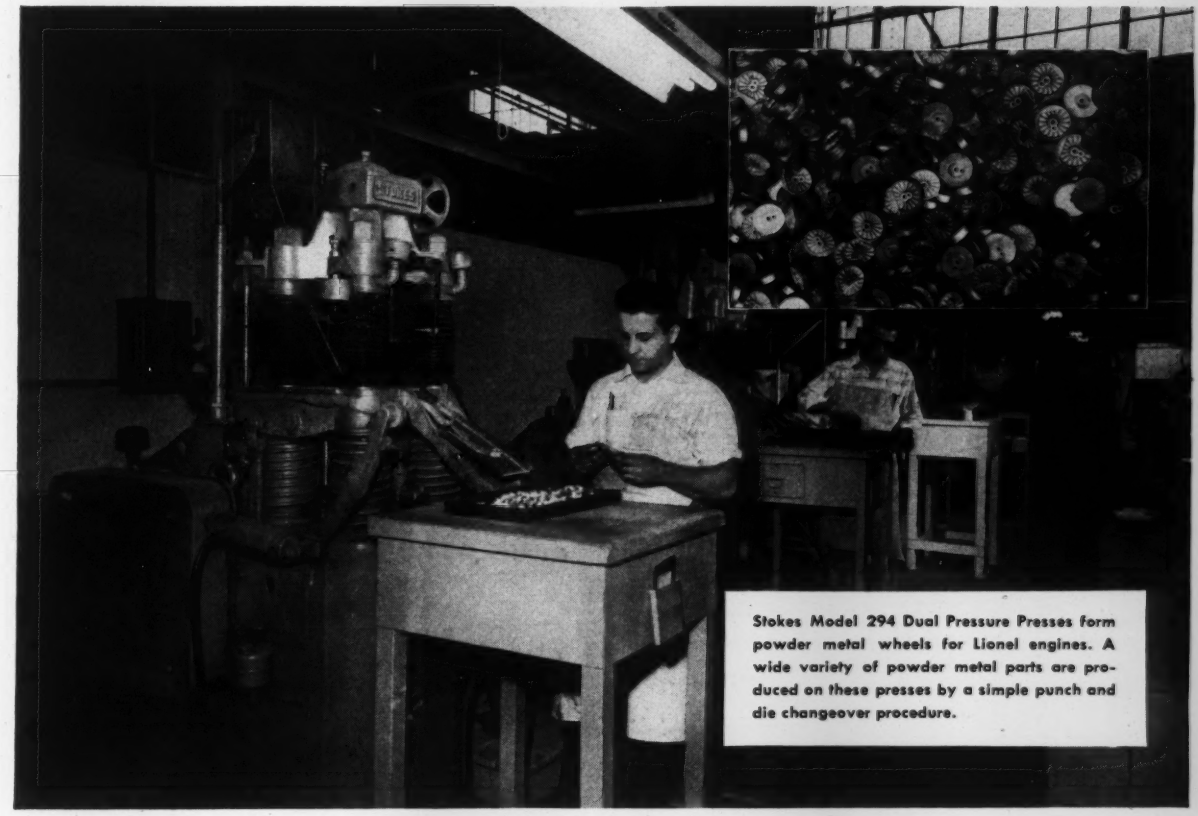
Write to us at Sandusky, Ohio. Ask for latest Bulletin #200.

SANDUSKY CENTRIFUGAL CASTINGS

FOUNDRY & MACHINE CO.

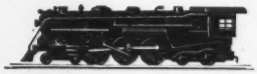
SANDUSKY, OHIO—Stainless, Carbon, Low-Alloy Steels—Full Range Copper-Base, Nickel-Base Alloys

For more information, turn to Reader Service card, circle No. 435



Stokes Model 294 Dual Pressure Presses form powder metal wheels for Lionel engines. A wide variety of powder metal parts are produced on these presses by a simple punch and die changeover procedure.

Stokes precision presses help Lionel model trains run on powder metal wheels



The name Lionel is synonymous with enjoyment to boys of every age. Since 1900, Lionel has manufactured hundreds of thousands of model train sets. In an effort to increase quality and reverse rising cost trends, Lionel purchased a battery of Stokes Powder Metal Presses several years ago to form many of the trains' parts. Today, over ½ million parts are produced each day on Stokes precision presses.

For example, Stokes presses form iron car wheels from powder metal. Unlike machine punched wheels, powder metal wheels are heavier. They lower the train's center of gravity and give it added stability. Finished wheels are more uniform and realistic. What's more, powder metallurgy has reduced wheel costs over 40%.

Perhaps powder metallurgy can cut your costs and save metal over conventional machining methods. It can aid you in getting properties of metals, alloys and mixtures unobtainable through other methods. And Stokes can help you determine production costs . . . handle complete laboratory production for sampling . . . include design and fabrication of punches and dies . . . and recommend types of equipment. Why not look into it further. Give Stokes a call . . . today.

Tabletting Division
F. J. STOKES CORPORATION
5500 Tabor Road, Philadelphia 20, Pa.

STOKES

For more information, turn to Reader Service card, circle No. 407

TYPE OF CLAD WIRE	DESCRIPTION	PROPERTIES
SEALING WIRES		
52 Alloy Clad Copper	Soft-glass sealing material for lead-in wires of electronic tubes, semiconductor devices and lamps.	Coeff. of exp. 102 x 10^{-7} in./in./°C
Dumet Copper Clad 42 Alloy	" " "	Coeff. of exp. 11.7 x 10^{-6} in./in./°C
Kovar Clad Copper	Hard-glass sealing material for lead-in wires for hermetically sealed electrical and electronic products.	Coeff. of exp. 60 x 10^{-7} in./in./°C
SPECIAL		
Copperweld Copper Clad Steel	High-conductivity, high-strength material for grid side rods in electronic tubes.	Resistivity 27.0 ohms/cir. mil ft. @ 68°F
Kulgrid® 64 Nickel Clad Copper	High-temperature conductor extensively used for aircraft spark plug electrodes.	
HIGH-TEMPERATURE CONDUCTORS		
Aluminum Clad Copper	Resistivity—13.0 ohms/cir. mil ft. @ 68°F	Operating range—up to 800°F
Kulgrid® 28 Nickel Clad Copper	Resistivity—13.85 ohms/cir. mil ft. @ 68°F	Operating range—up to 1000°F
Inconel Clad Copper	Resistivity—14.6 ohms/cir. mil ft. @ 68°F	Operating range—up to 1100°F
Oxalloy* 28 Stainless Steel Clad Copper	Resistivity—16.0 ohms/cir. mil ft. @ 68°F	Operating range—up to 1300°F
Nickel Clad Silver	Resistivity—11.3 ohms/cir. mil ft. @ 68°F	Operating range—up to 1500°F

*Trade Mark

SYLVANIA offers the most complete line of CLAD WIRES

Sylvania Clad Wires are in increasing demand in electrical and electronic manufacturing where single-metal or one-alloy wires cannot meet the requirements . . . particularly in high-stress, high-temperature, high-conductivity applications.

Unlike plating, the Sylvania cladding process literally slips a tube of one metal over a rod of another metal and draws them out together into a wire combining the qualities of both metals. These wires maintain exact ratios of core material to cladding material . . . each can be held to as little as 10% or as much as 90% of the finished wire.

These wires are far more uniform than plated wires. Alloy cladding over base-metal cores is perfectly practicable. Listed above are the Clad Wires now available in sizes from .500" to .001", either in stock or in process for fast finishing.

All of the wires listed above are standard production items . . . the largest line of in-process clad wires available from any supplier. Other clad wires can be supplied to order.

Sylvania produces precision fine wire in all three types: plated, alloy and clad. Our wealth of experience with all three is at your disposal at any time. Contact your Sylvania representative or write to: Sylvania Electric Products Inc., Parts Division, Warren, Pa.

SYLVANIA

Subsidiary of
GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

PARTS DIVISION

Custom Molded Plastics
Custom Metal Stampings
Custom Welded Parts
Custom Assemblies
Alloy, Clad, Plated Wire
Plated Metal Strip
Electronic Components
Fluorescent Components

For more information, turn to Reader Service card, circle No. 478

Automotive Power Steering Manufacturer Specifies

OSTUCO *Mechanical Seamless Tubing*

FOR SURFACE FINISH

Cold drawing Ostuco tubing through precision ring die on cold draw bench at Shelby mill. Mandrel controls and sizes I.D.

"Automotive components are our business. We have produced literally millions. And we're still learning every day.

"One of the lessons we learned early in the game is that you can't beat Ostuco tubing for surface finish. It cuts our machining costs, keeps us on top competitively.

"There are other reasons, too, why Ostuco tubing tops our preferred list. We like its consistently close tolerances and unvarying quality, shipment after shipment. You might say we like its *product integrity* . . . "

To learn more about what Ostuco tubing can do for *your* production, contact your Ohio Seamless representative, listed in the Yellow Pages, or the mill at *Shelby, Ohio — Birthplace of the Seamless Steel Tube Industry in America.*

AA-9431

OSTUCO TUBING

OHIO SEAMLESS TUBE DIVISION

of Copperweld Steel Company · SHELBY, OHIO

Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

SALES OFFICES: Birmingham, Charlotte, Chicago (Oak Park), Cleveland, Dayton, Denver, Detroit (Huntington Woods), Houston, Los Angeles (Lynwood), Miami, Moline, New Orleans (Chalmette), New York, North Kansas City, Philadelphia (Wynnewood), Pittsburgh, Rochester, St. Louis, St. Paul, Salt Lake City, Seattle, Tulsa, Wichita CANADA: Railway & Power Engr. Corp., Ltd. EXPORT: Copperweld Steel International Company, 225 Broadway, New York 7, New York

For more information, turn to Reader Service card, circle No. 416

PROTECTED BY Bonderite PARKER RUST PROOF CO. QUALITY CORROSION RESISTANT

Bonderite's best for Aluminum, too!

Better paint adhesion, better corrosion control

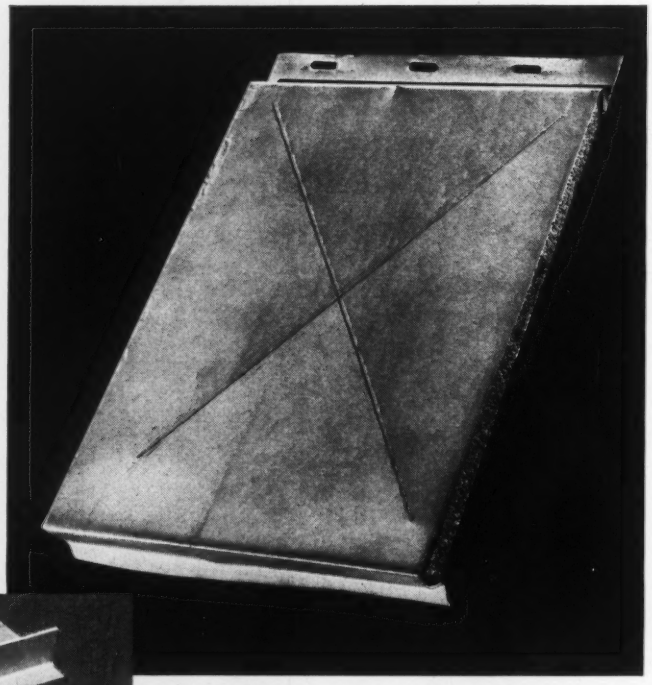
Here's the most famous name in the whole metal treatment field. Bonderite!

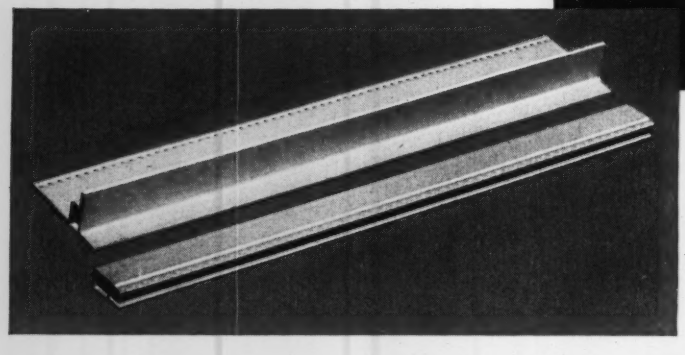
This is the product name that has meant finest finish protection and customer satisfaction to buyers of automobiles, home laundry equipment, refrigerators, metal furniture and other painted metal products for a generation.

This year, over 10 million Bonderite seals will be used on metal products to tell buyers they are getting the plus values of Bonderite protection.

As protection for aluminum, Bonderite's performance is equally spectacular. It controls corrosion, anchors paint.

Sell aluminum siding, awnings, windows, doors and panels that are protected by Bonderite. Sell with complete confidence that the product's good looks will last and last!





(Above): Regular 1-coat paint finish over section of Bonderite-treated aluminum siding. Formed after painting. Tested in salt spray 1500 hours. (Siding by Hastings Aluminum Products, Inc., Hastings, Mich.)

(Left): Aluminum window and screen frame sections Bonderized, painted in the strip, formed after painting. No breaks in finish anywhere! (Frame by The Security Companies, Detroit, Mich.)

Since 1914—leader in the field

Parker Rust Proof Company

2173 E. MILWAUKEE, DETROIT 11, MICHIGAN

BONDERITE corrosion resistant paint base	BONDERITE and BONDERLUBE aids in cold forming of metals	PARCO COMPOUND rust resistant	PARCO LUBRITE—wear resistant for friction surfaces	TROPICAL—heavy duty maintenance paints since 1883

**Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.*

For more information, turn to Reader Service card, circle No. 512

They Prescribed *Al* . . .

BUT Zn IS THE *RIGHT* Rx

Nine zinc die castings make up the greater part of this aspirin dispenser. As a result, the mechanism is dependable, durable, and resistant to atmospheric conditions found anywhere.

All slot machines have one common denominator. While manufacturing costs should be low, coin in the slot dispensers must "deliver the goods"—faithfully and consistently. This pre-supposes that the mechanism be durable enough to withstand the wear and tear of constant handling by people, not all of whom are gentle. It is not surprising therefore, to find that most of the working parts of such dispensers are die cast. The aspirin dispenser shown at left is typical. Inside the housing sections are two multi-barreled containers which hold the capsules of aspirin tablets. Each of these segments is approximately 4" long and contains 15 tubes. The two container castings must match exactly to insure smooth feeding of the contents across the joint.

Originally the parts were designed as aluminum die castings. The change to zinc was necessary because of the inability of the die casters consulted to produce the multi-barreled storage sections with sufficiently straight sides so that boring operations could be eliminated. As precision-cast in zinc only the simplest machine work is needed to finish the parts. A few holes are drilled to accommodate self-tapping screws, and a slot cut in the bottom storage section to accept the delivery mechanism. Had these parts been made by any other method, many more—and costly—operations would have been necessary to finish them.

DIECASTING is the Process . . . ZINC, the Metal

BUNKER HILL 99.99+% ZINC

Eastern Sales Agents

ST. JOSEPH LEAD COMPANY, 250 PARK AVENUE, NEW YORK 17

Sales Office For Pacific Coast

THE BUNKER HILL CO., 680 MARKET STREET, SAN FRANCISCO 4, CALIF.

ZN-142

BUNKER HILL

The Preferred Zinc

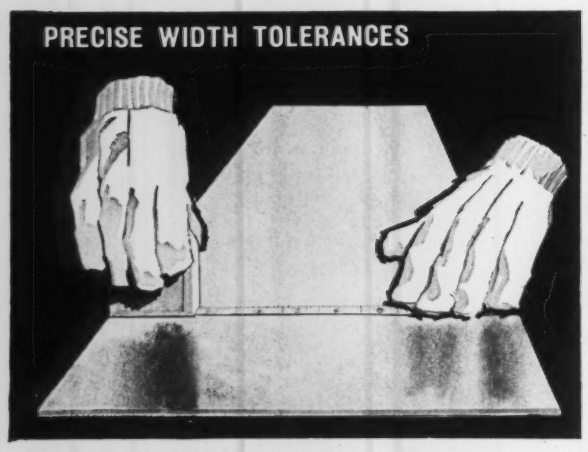
For more information, turn to Reader Service card, circle No. 454

Where precision is important...

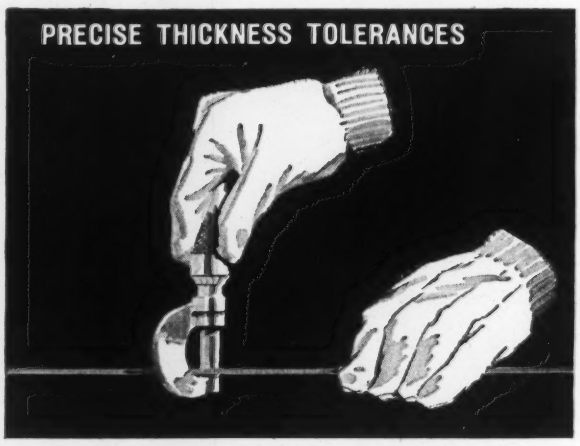
use USS Amerstrip, the "quality-

USS Amerstrip is a specialty product, rolled in quantities that permits production on precision machines, tailored to the customer's product specifications. When you use USS Amerstrip you get seven important "quality controls" not obtainable with other manufacturing methods.

The finish you get on your Amerstrip order has been specially prepared to meet *your* product's needs.



If your fabricating machines require a special width strip that's just what you'll get with Amerstrip. USS Amerstrip can be produced in any width under 24 inches . . . well within exacting tolerance limits.

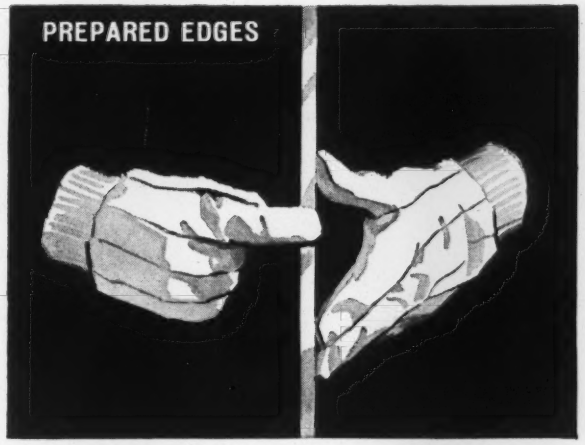


USS Amerstrip can be supplied in the thickness your machines demand. USS Amerstrip is fabricated on large production runs down to thickness tolerances as close as plus or minus .0005 inches.

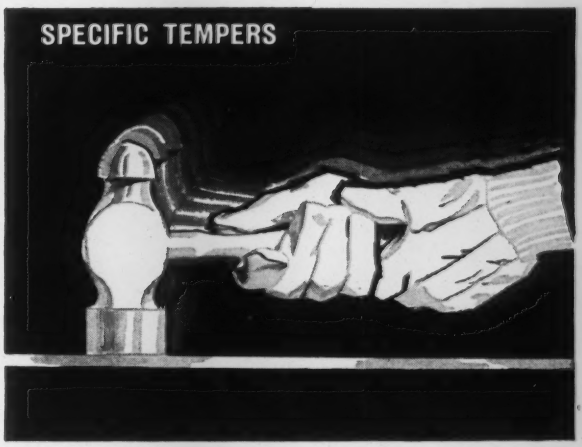
American Steel & Wire representatives are experts in the fabrication and application of USS Amerstrip Cold Rolled Strip. Whenever you have a need or problem involving cold roll let these experts show you how USS Amerstrip can do it better. Get in touch with our nearest representative or write to American Steel & Wire, Dept. 9263, 614 Superior Ave., N.W., Cleveland 13, Ohio.

USS and Amerstrip are registered trademarks

controlled" cold rolled strip steel



Because USS Amerstrip is produced in precision, order-size quantities, it can be supplied with the edge finish you need... square, standard, round, full round or bevel.



Whether your product must undergo a deep draw or other severe forming operation or require a special temper for rigidity, you'll get the exact temper you need when you order USS Amerstrip.

Whatever the size of your order . . . very large or very small, every coil of USS Amerstrip will be uniform in finish, in temper, in width and thickness. The use of USS Amerstrip will assure continuous production and high yields.

DESIGNED FOR END USE

This is really the sum total of all these other advantages. Because USS Amerstrip is "Quality-Controlled," because it is engineered to meet your needs, it assures you smoother, faster operation; a better, more salable finished product.

USS American Steel & Wire Division of United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
Tennessee Coal & Iron Division, Fairfield, Ala., Southern Distributors
United States Steel Export Company, New York

For more information, turn to Reader Service card, circle No. 537

Foils must be light—they must be steel There was a time when your very life depended upo

and tough enough to spring back unharmed after countering the intended death blow. These characteristics hav

STEELS FOR DESIGN

your blade. It had to be as light as human ingenuity could make it. But it also had to be strong,

made steel the most important metal in the history of man. For some modern, lightweight examples, turn the page ▷ ▷ ▷

CHAPMAN TRANSPORT INC.

STEELS FOR DESIGN

Stainless Steel builds a stronger, lighter trailer. This 40-foot trailer is one of the latest models designed and built by the Fruehauf Trailer Company. It's the strongest, lightest trailer in its class because it was built with Stainless Steel. The Stainless has a yield point of 120,000 psi, almost four times greater than competitive materials, so the walls, roof, and braces could be made thin and very light, yet they are rigid and strong. The exceptional corrosion resistance of Stainless Steel practically eliminates maintenance. This trailer will never have to be painted or refinished and it will still look clean and new after many thousands of miles.

High Strength Steel cuts cable reel weight 25%. The George Evans Corporation is the largest manufacturer of cable reels in the United States. Each of these reels has to carry and protect about $5000 worth of cable—seven tons of it. The reel must be strong and rugged or it will buckle under its load as it bumps over rocks and timbers in the field. It must *also* be exceptionally light, or freight costs will be exorbitant and field handling almost impossible. For a long time, these reels were made of wood and they lasted about two years. Then, the company started to make an all-steel reel, with the rims made of USS COR-TEN High-Strength Low-Alloy Steel. The COR-TEN Steel reels are much stronger and they weigh 25% less than wooden reels. They *cost less*, too, because they cut freight charges; they practically eliminate maintenance; and they will last about twenty years.

USS "T-1" Alloy Steel cuts tanker weight, increases payload. Trinity Steel Company of Dallas, Texas, makes LPG transport tankers and recently the company tripled production to meet the demand for its new, lightweight models. Trinity increased the payload of these tankers substantially by cutting the weight of the carrier itself as much as one-third. They used USS "T-1" Constructional Alloy Steel. Because "T-1" Steel is extremely strong—100,000 psi minimum yield strength—the tank walls are made about ⅓ thinner—with a comparable reduction in weight. And the weldability of "T-1" Steel meets the rigid ASME code that requires X-Ray and magnetic particle inspection of all joints.

USS, "T-1" and COR-TEN are registered trademarks

United States Steel USS

SEE HOW TENSILES OF SPECIAL HB MUSIC WIRE

COMPARE

SIZE	STANDARD HB	SPECIAL HB	MUSIC WIRE
.1620	219,000 min.	**249,000 min.**	249,000 min.
.1350	227,000 "	**258,000 "**	258,000 "
.0800	244,000 "	**276,000 "**	282,000 "
.0200	310,000 "	**320,000 "**	350,000 "

— at savings of up to 60%

You can use PAGE *Special* HB for many jobs where music wire has always been specified —and save up to 60% on your wire costs! PAGE *Special* HB is a hard-drawn, high-carbon steel wire, available in diameters from .162" to .020" (bright finish). Its tensile strength approaches that of music wire in all sizes — and in sizes .090" and coarser equals it! Check the chart above for tensile strengths of four typical diameters. If you now use music wire, it makes sense to investigate PAGE *Special* HB; you may be able to reduce your wire costs considerably.

PAGE is a logical source for other types of manufacturers wire, too. Why not see for yourself what PAGE quality wire can do to improve your product and lower your costs. And if you have an unusual problem requiring a special wire PAGE can help you there, too. The latest example of PAGE leadership is the development of ACCO Aluminized Wire; commercially pure aluminum bonded to a steel core.

ACCO

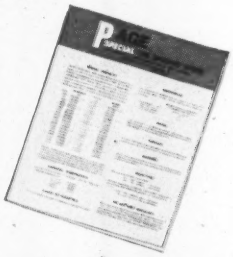
PAGE MANUFACTURERS WIRE

Page Steel and Wire Division • American Chain & Cable Company, Inc.

Monessen, Pa., Atlanta, Chicago, Denver, Detroit, Houston, Los Angeles, New York, Philadelphia, Portland, Ore., San Francisco, Bridgeport, Conn.

WRITE FOR DETAILS

Booklet DH-107A gives complete data on PAGE *Special* HB, including table of tensile strengths, chemical composition, dimensions, finishes, and other information. Write us at Monessen, Pa., for your copy —or for information on any other PAGE wire.



PAGE — *the source for answers to wire problems*

For more information, turn to Reader Service card, circle No. 431

A pretty tough case

An Eastman plastic helped Emerson solve a material selection problem

One of the toughest problems in designing a new product sometimes proves to be choosing the right material.

The Emerson all-transistor pocket radio shown above is a good illustration of how the familiar "process of elimination" often is used in evaluating materials to find one whose properties satisfy all the demands of a specific application.

Here, the need was for a tough housing that would have beauty and light weight, yet be rugged enough to endure hard knocks and outdoor exposure hazards. Important, too, since the radio would be spending a good bit of time in the user's hand, the case had to be made of a material that would be pleasant to the touch.

Only in Tenite Butyrate plastic, did Emerson find a material that met all their needs. Butyrate is an easy-to-mold, lightweight thermoplastic with outstanding resistance to impact and weathering. Its surface is lustrous. Its low heat conductivity assures a warm friendly "feel." And, its availability in both clear and colored forms simplifies assembly and decorating operations. The main case body is molded of colored Butyrate—color that cannot peel or wear off, because it is an integral part of the plastic. The back and one-piece front are molded of crystal-like transparent Butyrate which permits gold-lacquered areas on the inner side to show through.

If you have a product development—or product improvement—problem, look to the Tenite plastics for a possible solution. For more information write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

TENITE
BUTYRATE
an Eastman plastic

The Emerson Model 555 "All-American" transistor pocket radio is manufactured by Emerson Radio and Phonograph Corp., 14th and Coles Streets, Jersey City 2, New Jersey. Its case is molded of Tenite Butyrate by Worcester Moulded Plastics Co., 14 Hygeia Street, Worcester 8, Massachusetts.

For more information, circle No. 370

"Dad believes in good guns and good gun manners"

"He just bought me a new gas-powered Hahn BB rifle. It's real sharp and shoots straight, but he won't let me use it alone until I've learned good gun manners."

Hahn BB guns, styled after famous lever-action Western frontier rifles, have the look and feel of Dad's guns—and they shoot straight. This is due to the accuracy of the barrels. They are made from commercial grade Superior carbon steel tubing —known for the consistent uniformity of its ID finish, free machining characteristics and economy.

Examples of other unusual applications of this Superior tubing

- Carbon steel rectangular tubing for collimating tubes in a research reactor (.900 in. x .400 in. ID x .025 in. wall in 10-ft. cuts)
- Specially conditioned ID tubing in long lengths used as high pressure diesel lines on earthmoving equipment (¼ in. OD x .088 in. ID)
- Cadmium plated compression sleeves for connecting the steel core of ACSR high tension cable (.404 in. OD x .179 in. ID in 5-in. cuts)
- 2½ million ft. of carbon steel tubing in random lengths for the gear pinion in the timing fuse of artillery shells (.204 in. OD x .067 in. ID)

Filling tubing orders that range from a few feet to millions, in a wide variety of materials, shapes and sizes, calls for the resources Superior has to offer. Why not investigate the advantages of using us as a source of tubing. Bulletin 41, a guide to the selection and application of Superior tubing, is yours for the asking. Write Superior Tube Company, 2006 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ⅝ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, 5710 Smithway St., Los Angeles 22, Calif. • RAymond 3-1331

For more information, turn to Reader Service card, circle No. 394

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A complete line of quality products and processes developed primarily as a result of helping manufacturers like yourself solve their metal finishing problems. If one of our present products does not meet your needs, we'll be glad to work with you to find an answer to your problem.

IRIDITE® Chromate Conversion Coatings for Non-Ferrous Metals.

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ISOBRITE® *Chemically Different* Plating Brighteners.

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for Metal Finishing

Process Engineered—Single pieces of equipment or all equipment necessary for a finishing operation—evaluated, designed, fabricated, installed and tested to match exactly your particular process. Ask about our *Process Engineering Service.*

WAGNER RECTIFIERS

Silicon and Selenium, built to exacting specifications for long life, trouble-free service.

WAGNER AUTO-LOADERS

for fast, economical transfer of racks and parts, conveyors to plating machines, between conveyors.

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BARRELS, TANKS and other equipment.

CHEMICALS AND SUPPLIES

Prompt service on a wide variety of daily-use necessities for the plating room, delivered from warehouse stocks strategically located in cities in metalworking areas.

FLAT•TOP® **ANODES**

In copper and zinc.

LECTROCOP® **FLAT COPPER ANODES**

CADMIUM, WHITE BRASS AND TIN ANODES in most efficient shapes. Acid Replacements, Buffs, Chemicals, Cleaners, Maintenance Materials.

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Ask your Allied Field Engineer about our Subscription Plan which combines your new nickel purchases with a service to recast *your* butts and spears, resulting in substantial savings.

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For more information, turn to Reader Service card, circle No. 433

from contact shoe beams . . . to ship fenders . . .

GAMBLE solves problems with WOOD!

Contact shoe beams on subway cars hold the apparatus for picking up power from the third rail. The problem: could wood (with its obvious advantages) hold the required dimensional tolerances and provide the necessary dielectric strength? The answer: yes, in the form of a laminated hard maple beam engineered by Gamble Brothers.

The "ship fender" problem was different. Who in the world had the wood-engineering knowledge and physical plant to produce the "king-size" wood laminations? The answer again: Gamble Brothers.

Design problems like these are "all in a day's work" to the wood engineers at Gamble Brothers —a unique organization designing and building a wider variety of wood products than any other U. S. woodworking company. Today they're working on projects in three principal areas: (1) improvement of present wood products (2) development of new wood products (3) product development in combinations of wood and other materials.

Why not present *your* design or component problem to Gamble Brothers? WOOD may be the answer!

FREE booklet illustrates GAMBLE services

This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Brothers, Inc., 4627 Allmond Ave., Louisville, Ky.

If the problem involves wood, Gamble can help!

GAMBLE BROTHERS GB GUARANTEED BOND

GAMBLE BROTHERS, INC.

4627 Allmond Avenue, Louisville, Kentucky

For more information, turn to Reader Service Card, circle No. 390

For the best in phosphating results

ask Oakite

OVER 50 YEARS CLEANING EXPERIENCE • OVER 250 FIELD SERVICE MEN • OVER 160 MATERIALS

One of these CrysCoat® processes is job-matched to your pre-paint needs

ALL Oakite CrysCoat phosphating processes lock paint on . . . lock corrosion out, with a tight, dense integral coating on steel. But there's one that's *job-matched* to your present requirements . . . to give you the results you want for the lowest unit cost.

Oakite CRYSCOAT 47: heavy, fast-coating iron phosphate. Iron phosphating at its best. Cleans off average fabricating oils and soils as it phosphates; produces a premium quality coating, heavier and faster than ordinarily obtainable. Increases corrosion resistance. Conserves spray washer time.

Oakite CRYSCOAT 87: smooth, paint-saving iron phosphate. Thin, dense, smooth iron phosphate coating for tank or spray set-up uses only 3 stages, since it cleans as it phosphates. Saves time, equipment, easy to control. Takes less paint for a smooth finish, and gives at least double the 250 hour specified minimum of salt spray resistance.

Oakite CRYSCOAT 89: economical, iron phosphate. Iron phosphate process works in spray washing machine without foaming. Easy to control, requires no stainless steel equipment. Provides both cleaning and phosphating action simultaneously.

Oakite CRYSCOAT HC: heavy duty zinc phosphate. For tank application. Creates a heavy zinc phosphate coating for severe service conditions. Meets and surpasses standard Government specifications. Exceeds the 150 milligram per square foot requirement; up to 1200 milligrams obtainable.

Oakite CRYSCOAT SW—single package zinc phosphate. Easy to control zinc phosphate process using single material. For spray washer or tank application. Coatings meet specifications on weight and protection. Offers long solution life.

Oakite CRYSCOAT MP—heat-saving zinc phosphate. Produces zinc phosphate coating at low temperature, on steel, cadmium, zinc and magnesium. Keeps sludging to a minimum. Process suitable for spray washer or tanks. Satisfies all specifications on weight and protection.

Oakite CRYSCOAT FG—smooth, dense zinc phosphate. Develops a fine grain zinc phosphate coating. May be used in spray washer or tank immersion. Low to moderate temperature process. Promotes a smooth paint finish.

Products with a CrysCoated finish look better and last longer. Ask Oakite about these and other CrysCoat processes. Or ask for illustrated Bulletins that give full details. Oakite Products, Inc., 26 Rector Street, New York 6, N. Y.

it PAYS to ask Oakite

OAKITE®

50 *1909-1959 years' leadership in industrial cleaning*

SCIENCE

For more information, turn to Reader Service card, circle No. 377

High voltage "lightning" discharge at a Malleable test block.

Toughness is Malleable

Under the slamming, bruising strain of a bulldozer's roughshod ride . . . inside the battering air hammer . . . against the repetitive concussion of a machine gun's smashing action . . . wherever conditions are really brutal, Malleable iron castings prove their ruggedness.

When you're looking for toughness, it will pay you to investigate Malleable castings. Contact one of the progressive firms that displays this symbol—

MEMBER
MALLEABLE
CASTINGS COUNCIL

If you wish, you may inquire direct to the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio, for information.

(Advertisement)

New Malleable Irons Meet Gruelling Service Tests

Toughness is a vital requirement in stressed parts. Each application, however, requires a particular combination of physical characteristics to be sufficiently "tough."

Whatever the specific requirements, one of the finest groups of materials available is the Malleable irons, as illustrated in the tables below.

Tensile Properties—A.S.T.M. Minimum Specifications
Standard and Pearlitic Malleable Irons

Designation	Tensile Strength p.s.i.	Yield Strength p.s.i.	Elongation % in 2 in.	Designation	Tensile Strength p.s.i.	Yield Strength p.s.i.	Elongation % in 2 in.
Standard				53004	80,000	53,000	4
35018	53,000	35,000	18	60003	80,000	60,000	3
32510	50,000	32,500	10	80002	100,000	80,000	2
Pearlitic							
45010	65,000	45,000	10				
45007	68,000	45,000	7				
48004	70,000	48,000	4				
50007	75,000	50,000	7				

Strengths up to 135,000 p.s.i. tensile and 110,000 p.s.i. yield are produced commercially under individual producers' specifications.

Other Mechanical Properties
Standard and Pearlitic Malleable Irons

	Standard	*Pearlitic*
Modulus of Elasticity in Tension, p.s.i.	25,000,000	26,000,000—28,000,000
Ratio of Fatigue Strength to Tensile Strength	0.54	0.40—0.50
Shear Strength—% of Tensile Strength	80—90%	70—85%
Torsional Strength	Approximately equal to Tensile Strength	
Compressive Strength, p.s.i.	200,000	250,000

Malleable's toughness is illustrated in a severe test conducted by a manufacturer of cab-over-engine trucks. To be absolutely sure of the strength and toughness of a variety of components in the cab, including the critical Malleable iron cab support hinges, a truck was crashed at high speed into a barricade of ice. Result—no hinge damage, even though the truck was seriously battered.

Service-Demonstrated Toughness

Highway railing posts demonstrate Malleable castings' use where impact resistance is critical. As an example, thousands of Malleable railing posts line the Connecticut State Thruway. The State Highway Department reports that there have been no failures of the Malleable iron posts although other materials have failed in several cases.

It is also because of Malleable's toughness that so many of the highest quality hand tools are made of Malleable iron. One leading tool manufacturer tests the quality of its pipe wrenches by using a trick well known as the best way to break a wrench. The wrench jaws are put on a rigid bar, a long pipe is slipped on the handle, and the tester heaves his weight downward on the pipe. Because of their confidence in Malleable's toughness, this company unconditionally guarantees every Malleable wrench housing against distortion and breakage. Another hardware manufacturer makes a similar guarantee against breakage on its line of Malleable vises.

But Malleable iron's proven performance in field service is only one reason for its wide use. To this, you must add Malleable's low first cost, design flexibility, and excellent machinability. This combination offers unique advantages over other metals.

Design and Production Assistance Available

To assist in the use of Malleable castings, a special bulletin on toughness—Data Unit No. 105—is available from the Malleable Castings Council, Union Commerce Building, Cleveland 14, O. These bulletins and engineering and planning assistance are also readily available to you from any member of the Malleable Castings Council.

These companies are members of the

MALLEABLE CASTINGS COUNCIL

CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Link-Belt Company, Indianapolis 6
Muncie Malleable Foundry Co., Muncie
Terre Haute Mall. & Mfg. Corp., Terre Haute

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW JERSEY
Meeker Foundry Company, Newark 4

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Canton Malleable Iron Co., Canton 5
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

For more information, turn to Reader Service card, circle No. 516

News about COATINGS FOR METALS
from Metal & Thermit Corporation

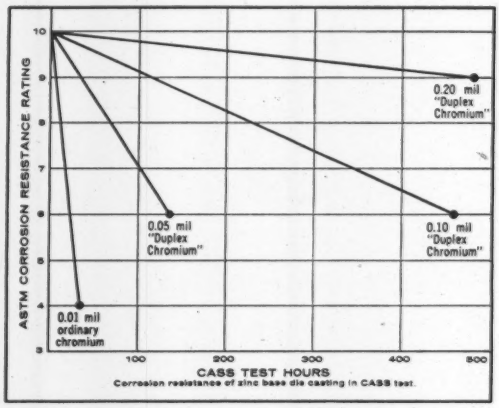
How to get the optimum protection of bright chromium plating

There are three requisites to increasing corrosion protection from chromium plating. (1) The deposit must be sufficiently thick. (2) There should be a crack-free chromium base topped by a special, finely cracked chromium deposit. (3) The plate should be more uniformly distributed over the part, so that recessed areas, too, are assured at least 0.03 mils minimum chromium thickness.

All of these requirements are easily met through UNICHROME SRHS® CHROMIUM plating processes. Work done for the automotive industry, long plagued by corrosion of brightwork in outdoors exposure, provides a good case in point.

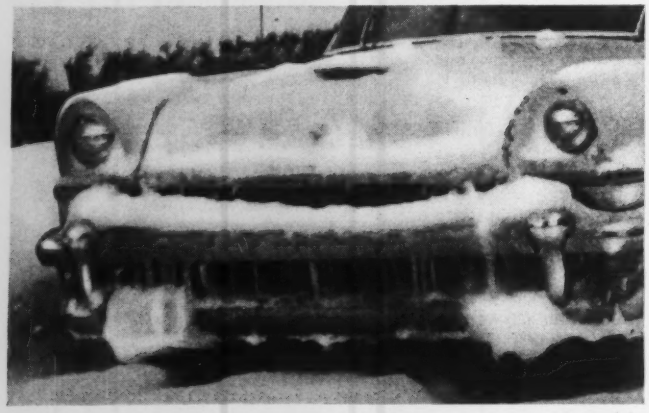
AN ANSWER TO OUTDOOR CORROSION

Note the results in the chart at right. In all cases, the thickness of undercoats was kept constant. Only the chromium plate was varied... from ordinary to "Duplex", and progressively thicker. M&T "Duplex Chromium" calls for first using Unichrome Crack-Free Chromium and its ability to throw into recesses and give a more uniform and fracture-free plate. This is followed by another deposit of Unichrome SRHS Chromium, with its *controlled* cracking. With increasing thickness, the protection increased tremendously. Durability as determined by rigorous, accelerated corrosion testing techniques was multiplied as much as *20 times*.



Zinc die cast specimens, all plated with 0.75 mil copper and 0.75 mil nickel prior to chromium lasted as shown above in the severe CASS test (Copper accelerated acetic acid salt spray). Ordinary chromium fared poorly. Optimum protection was approached by using Crack-Free Chromium and increasing the deposit thickness.

Despite severe service conditions, automotive brightwork can stay bright now, due to the additional corrosion protection that M&T "Duplex Chromium" provides.



WIDELY USEFUL FINISH

While the above case concerns itself specifically with an automotive problem, it indicates what thicker chromium in general, and crack-free chromium in particular can do for other design problems involving corrosion and wear. This plate blocks infiltration of corrosives to underlying metal.

Technical Papers giving full details on the advantages of thicker chromium deposits are available for the asking. Write METAL & THERMIT CORPORATION, Rahway, New Jersey.

METAL & THERMIT
CORPORATION

For more information, turn to Reader Service card, circle No. 476

DESIGNED IN CELANESE FORTIFLEX...

CONTAINER FOR VAPORIZER
Molded in Fortiflex for General Electric, Bridgeport, Conn., by Air Formed Products Corporation, Nashua, N. H.

Blow molded plastic puts steam in vaporizer design

Sometimes a material and a process make a natural team —as in the case of Fortiflex linear polyethylene and blow molding. Together, they make it possible to redesign products for better quality and greater economy.

In this blow molded bottle for the new G.E. Vaporizer, Celanese Fortiflex (a non-conductor) provides added insurance against shorting of the electrical element and contributes to safer operation. Fortiflex withstands boiling temperatures without softening. The blow molding method makes it possible to produce this difficult shape quickly and economically in large scale production. Mold costs are substantially reduced. With a capacity of nearly a gallon, the bottle weighs little more than 12 ounces and provides steam for 12 hours without refilling. Molded-in bottle colors are pink and blue.

If you need a hollow component that has good strength, why not see whether a blow molding of Fortiflex will meet the requirements? We'll be glad to send you information on both process and material.

Celanese® Fortiflex®

Fortiflex...a Celanese plastic

Canadian Affiliate: Canadian Chemical Company Limited, Montreal, Toronto, Vancouver.
Export Sales: Amcel Co., Inc., and Pan Amcel Co., Inc., 180 Madison Avenue, N.Y. 16.

For more information, turn to Reader Service card, circle No. 540

TYPICAL PHYSICAL AND CHEMICAL PROPERTIES OF FORTIFLEX

Properties of Fortiflex "A" Related to Melt Index

PHYSICAL PROPERTIES	ASTM METHOD	UNITS	FORTIFLEX RESINS A-20	A-70	A-250	A-500
Melt Index	D-1238-52T	—	0.2	0.7	2.5	5.0
Heat Distortion Temp. (66 psi)	D-648-45T	°F.	185	185	180	180
Brittleness Temp.	D-764-52T	°F.	—200	—180	—160	—100
Impact Strength, Izod (1/8" x 1/2" injection-molded bars)	D-256-54T	ft. lb./in. notch	23	18	13	3
Tensile Strength, Max., 0.2 in./min.	D-638-52T	psi.	3700	3600	3500	3300
Elongation, First Tensile Yield Point	D-638-52T	%	25	25	25	25

Properties of Fortiflex "A" Not Affected by Melt Index

PHYSICAL PROPERTIES	ASTM METHOD	UNITS	VALUE
Density		g/cc.	0.96
Refractive Index	D-542-50	n_D^{25}	1.54
Hardness, Shore D	D-676-49T		65
Stiffness	D-747-50	psi.	150,000
Water Absorption (1/8" specimen, 24 hr. immersion @ room temp.)	D-570-54T	%, wgt. gain	<0.01
Flammability	D-635-44	in./min.	1.0
*Mold Shrinkage, length		in./in.	0.03 to 0.05
width		in./in.	0.02 to 0.04

Measured on injection molded tensile bar. Mold shrinkage depends on part design and molding conditions.

Celanese Corporation of America, Plastics Division,
Dept. 102-S,
Please send: ☐ more information on, ☐ test quantities of Fortiflex.

Name _____ Title _____

Company _____

Address _____

City _____ State _____

. . . economical alternative for solid and clad metals and alloys

Kanigen®

Stainless Steel Reactor Tube Bundle—
Inside of tubes, outside of tube sheet and hub Kanigen plated to reduce the danger of stress corrosion cracking.

KANIGEN, General American's unique process for chemical nickel alloy plating on most metals and alloys, offers an opportunity for large savings on chemical equipment.

KANIGEN makes possible the use of inexpensive basis metals for tankage, valves and piping, storage and reaction vessels. It is particularly satisfactory for austinitic stainless steels when stress corrosion cracking is a problem.

Complex shapes that vary in size from a 20,000 gallon tank car to a tiny control valve can be given a uniform coating of the required thickness with Kanigen. Coating may be done by rack, jig or barrel methods.

You can get **KANIGEN** chemical nickel alloy plating from General American at Sharon, Pa.; East Chicago, Ind.; or Compton, Cal., and from licensees in many cities. For detailed information or technical advice, call or write. You'll find... *IT PAYS TO PLAN WITH GENERAL AMERICAN.*

KANIGEN is a trademark which identifies chemical nickel coating by General American Transportation Corporation and its licensees, the product resulting therefrom and compositions produced by them for use in chemical nickel coating.

Write for Technical Bulletin #258

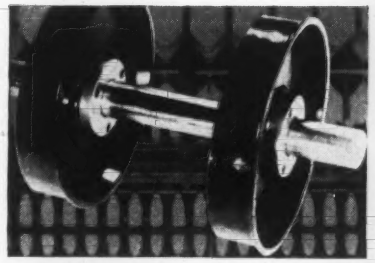
KANIGEN DIVISION
GENERAL AMERICAN TRANSPORTATION CORPORATION
135 South LaSalle Street • Chicago 3, Illinois

KANIGEN GENERAL AMERICAN TRADE MARK

For more information, turn to Reader Service card, circle No. 474

PRODUCT-DESIGN BRIEFS FROM DUREZ

- **impact strength comes down in price**
- **fast-curing phenolic cures a cost problem**
- **new idea for closures**



High impact at low cost

These big pulleys help drive huge spinning frames made by Roberts Co., Sanford, N. C., a leading manufacturer of textile machinery.

Until recently, the pulleys were made of stamped metal or heavy cast iron. Designers looked for a better material—strong, dimensionally stable, low in cost. They found it in *Durez 18683*.

This new sisal-filled phenolic solves the cost problem of high-impact parts in three ways:

1. It costs only pennies more than general-purpose wood-flour-filled phenolics.
2. It molds by simple compression or transfer methods, using standard presses, standard pressures, standard dies.
3. It cures as fast as general-purpose compounds.

Durez 18683 molds dimensionally stable parts with impact strength of 1.4 ft. lb./in. Molded parts are self-extinguishing, have excellent resistance to humidity, and can meet U/L requirements for attached electrical contacts. You'll find that *18683* opens the way to savings on hundreds of applications where higher-cost materials are used now.

Consider it for heater and air-conditioner housings, instrument panels. Specify it for gears, wheels, pulleys, electric motor end bells—wherever you need impact strength and want it at lower cost.

The sooner you investigate *Durez 18683*, the sooner you can start saving with it! For bulletin, data sheet and/or evaluation sample, mail the coupon today.

Torrid tempo

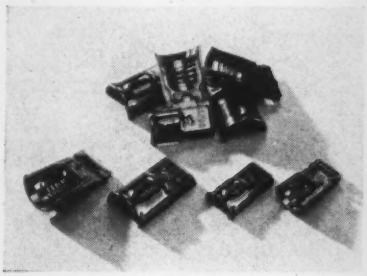
Rapid production is beating out a new rhythm of lowered costs for the makers of these small lamp sockets (center column), Noma Lites, Inc.

The key notes are smart redesign, use of multi-cavity molds, and an exceptionally fast-curing Durez phenolic.

Formerly, the manufacturer bought one-piece sockets, forced metal screw shells into them, applied pitch to protect against moisture, then laboriously soldered in the wires.

Zip! Now, threads are molded into the split sockets by the molder, Holyoke Plastics Company Inc. Wires are laid across the socket halves. A simple metal clip joins the halves and pierces the wires with contacts.

Whoosh! Socket halves are molded 80 at a time. Into the molds goes speedy *Durez 265*, general-purpose compound that cures in a few seconds. Even at this dizzy rate, its batch-to-batch uniformity assures consistent molding.



Hurry! Want to snap things up a bit? *Durez 265* can probably help you do it. To see how, dash right over to your molders. Or shoot us coupon for data on *265* and other GP molding compounds.

A cap can be pretty

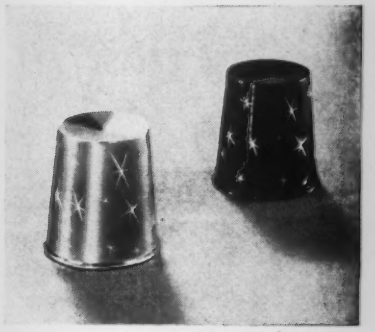
Not so long ago, you couldn't get this decorative effect in a molded plastic closure. Now you can.

It's done by wiping color into the debossed design. Debossing used to be the crux of the problem, because of the undercuts. It was impossible to make a workable mold cavity by machining, hobbing, or casting.

The solution: electroforming. The mold is built up in nickel around a soft, resilient master, which is then withdrawn from the cavity.

The process is a development of Armstrong Cork Company and Electromold Corporation. It gives the designer a new freedom—permits intricate textured effects like leather and wood grain, as well as the simpler ones you see here.

Durez is in the picture, too. Versatile phenolics, especially formulated for bottle and container caps, provide the requisite impact strength, resist chipping and cracking, and do not bleed when in contact with alcohol. If these qualities might help you uncork a closure idea or unbottle a bottleneck, we suggest you contact your molder on the use of Durez phenolics for closures.



For more information on Durez materials mentioned above, check here:

- ☐ High-impact low-cost phenolic, *Durez 18683* Bulletin and data sheet
- ☐ Evaluation sample of *Durez 18683*
- ☐ *Durez 265* (data sheet) and descriptive Bulletin 400

Clip and mail to us with your name, title, company address. *(When requesting samples, please use business letterhead.)*

DUREZ PLASTICS DIVISION

1409 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS

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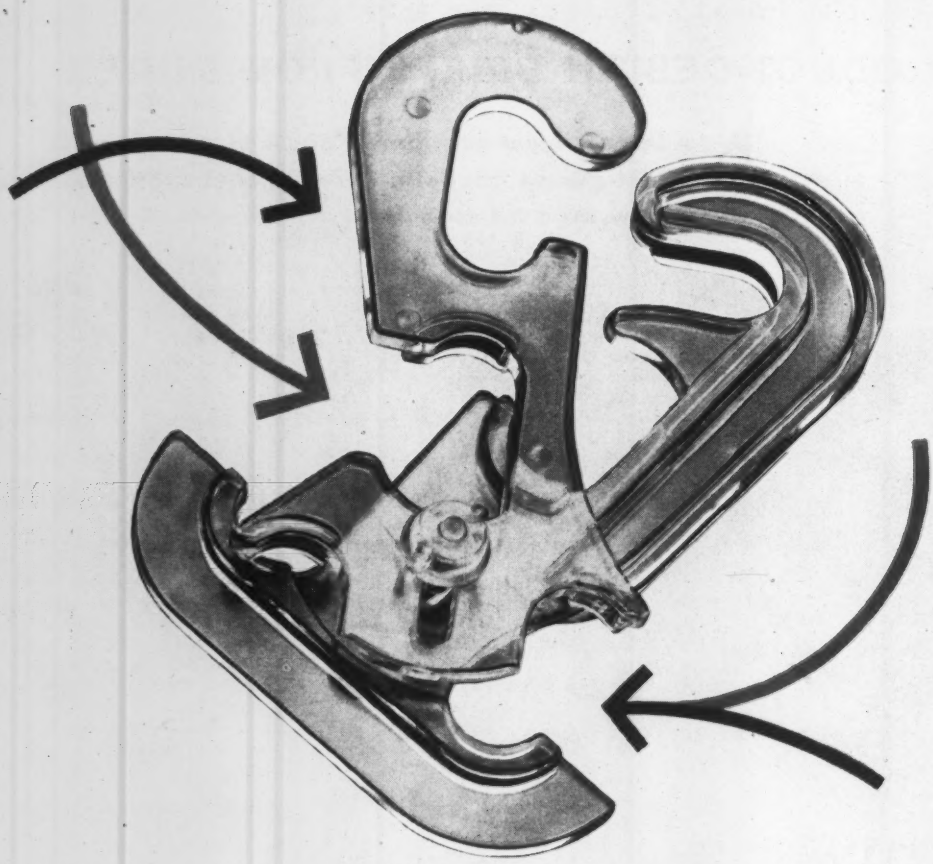

This molded plastic part hangs up a record 60% savings

Could be abstract art. Actually, it's a brand new molded plastic device for hanging both low and high voltage power cables—saves up to 60% of the cost of running power through heavily timbered areas. In designing this 15¾ oz. 4-part suspension clamp for injection molding, we worked with customer engineers—adapting their design to custom molding requirements. The selection of molding material—Methyl Methacrylate—assured the right electrical and physical properties, and the ability to withstand all types of weather. This is just *one* angle of every plastic molding job. Because we mold all types of materials and offer full range (small to large) compression, injection and transfer molding facilities, we're free to make unbiased recommendations . . . to provide the material and method of most value to you. For more information, call or write.

CHICAGO MOLDED
PRODUCTS CORPORATION
1026 North Kolmar Avenue, Chicago 51, Illinois

For more information, turn to Reader Service card, circle No. 487

CASE HISTORIES FROM MT. VERNON FILES

University makes 3 speakers from 1 Mt. Vernon die casting

The advent of stereo has brought about a demand for smaller cabinets and posed a problem for speaker engineers: design a small moderately priced unit capable of sound reproduction as good as that of present day speaker systems 3 to 4 times its size.

University engineers came up with 3 answers—3 new 8 inch speakers with outstanding performance characteristics—made of highest quality materials, with a better finish than ever...all at greatest possible economy thanks to the use of Mt. Vernon Die Castings.

This zinc pressure die cast "basket" provides a universal 8" frame for three different speakers: 1—a full range 3 way diffaxial, 2—a standard woofer, and 3—a new type high compliance woofer. This single part, formerly made of several stampings, contains the supports, flanges, slots, ribs, holes, studs and channels for all three models. It possesses all the rigidity and dimensional stability needed to assure permanent centering of the speaker cone, voice coil and magnetic element at increased power ratings.

Designed to very close tolerances, the castings are dependably uniform from speaker to speaker. They offer better design, greater rigidity and reliability than the assembled stamped basket at no increase in cost. Best of all, final speaker assembly is speeded up with fewer steps, resulting in greater economies, enabling University to offset steadily increasing general production costs. The finished products have a superior quality look that matches their superlative performance.

Back and front the casting is intricate, and the die even more so. However, Mt. Vernon's complete four-fold service takes these complex casting assignments in stride, gives service that more than satisfies...service that keeps customers happy for years and years...in the case of University Loudspeakers, Inc., of White Plains, N. Y....for over 15 years.

If you too would like to switch to die castings, let's talk it over. A call to your nearest sales representative will get you fast service.

MT. VERNON
DIE CASTING CORP.
STAMFORD CONNECTICUT

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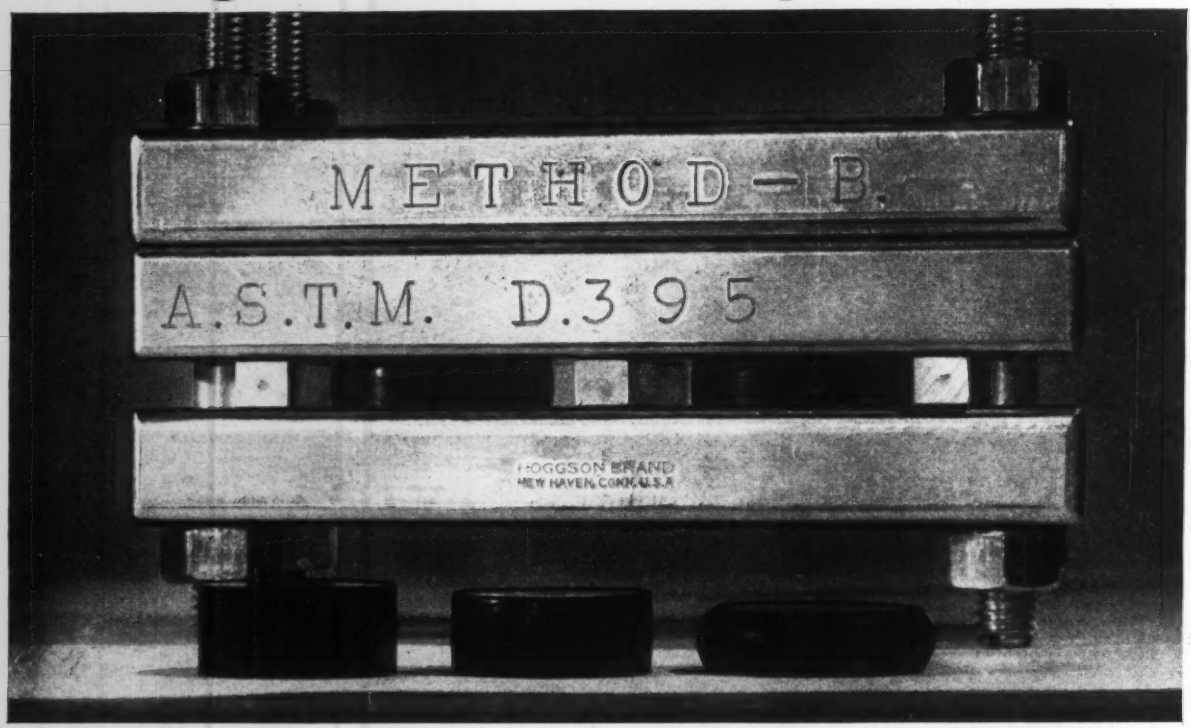
3M COMPANY CHEMICALS

THE RAW MATERIALS OF PROGRESS

fluorel*

BRAND ELASTOMER

Shrugs off heat and compression set



Left to right foreground: half-inch discs of FLUOREL Elastomer before and after test; standard elastomer after test. Test conditions: 25% deflection for 70 hours at 350°F. FLUOREL Elastomer will set only 30% of original deflection when released.

FLUOREL Brand Elastomer is a highly fluorinated synthetic rubber that maintains excellent resistance to compression set, even at extreme temperatures. A half-inch disc of FLUOREL Elastomer, for example, deflected 25% for 70 hours at 350°F, will set only 30% of the original deflection when released.

FLUOREL Elastomer also successfully resists corrosive chemicals, fuels, solvents and ozone . . . is rated for continuous service at temperatures of 400°F . . . tolerates 600°F temperatures, and higher, for shorter periods under some service conditions.

FLUOREL Elastomer is readily processed on standard rubber compounding and fabricating equipment. It can be molded or extruded, and bonded to most metals. These qualities make it ideal for many applications in the aircraft, automotive, missiles and chemical industries . . . wherever resistance to heat, compression set and corrosion are required of an elastomeric material. For full performance data, write: 3M, Chemical Division, Box KAR-99, St. Paul 6, Minnesota.

*FLUOREL is a trademark of Minnesota Mining and Manufacturing Company.

CHEMICAL DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

For more information, turn to Reader Service card, circle No. 481

III

KNOW YOUR ALLOY STEELS . . .

This is the third of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

What Does Grain Size Mean In An Alloy Steel?

The grain size of alloy steels is generally understood to mean austenite or inherent grain size, as indicated by the McQuaid-Ehn carburizing test. Austenite grain size should be distinguished from ferrite grain size, which is the size of the grains in the as-rolled or as-forged condition with the exception of those steels that are austenitic at room temperature. When steel is heated through the critical range (approximately 1350 to 1600 deg F for most steels, depending on the composition), transformation to austenite takes place. The austenite grains are extremely small when first formed, but grow in size as the temperature above the critical range is increased, and, to a limited extent, as the time is increased. It is apparent, therefore, that both time and temperature must be constant in order to obtain reproducible results.

When temperatures are raised materially above the critical range, different steels show wide variations in grain size, depending on the chemical composition and the deoxidation practice used in making the heat. Heats are customarily deoxidized with aluminum, ferrosilicon, or a combination of deoxidizing elements. Steels using aluminum or other deoxidizers in carefully controlled amounts maintain a slow rate of grain growth at 1700 deg F, while heats finished with other deoxidizers, usually ferrosilicon, develop relatively large austenite grain size at temperatures somewhat below 1700 deg F.

The McQuaid-Ehn test is the one ordinarily used for determining grain size. Steel is rated with a set of eight ASTM charts that are compared one at a time with a specially prepared steel sample until one is found to match. Number 1 grain size, the coarsest, shows 1½ grains per sq in. of steel area examined at 100 diameters magnification. The finest chart is Number 8, which shows 96 or more grains per sq in. at the same magnification.

Properties Affected by Grain Size

Fine-grain steels (grain sizes 5, 6, 7, and 8) do not harden as deeply as coarse-grain steels, and they have less tendency to crack during heat-treatment. Fine-grain steels exhibit greater toughness and shock-resistance—properties that make them suitable for applications involving moving loads and high impact. Practically all alloy steels are produced with fine-grain structures.

Coarse-grain steels exhibit definite machining superiority. For this reason a few parts which are intricately machined are made to coarse-grain practice.

The correct specification and determination of grain structure in steel is a subject that has been given long study by Bethlehem metallurgists. If you would like suggestions on this or any other problem concerning alloy steels, these men will be glad to give you all possible help.

In addition to the entire range of AISI alloy steels, Bethlehem produces special-analysis steels and the full range of carbon grades.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

For more information, turn to Reader Service card, circle No. 483

"We found the big difference in PVC

. . . and an important one, too," reports one of the nation's leading chemical companies. A PVC pipe that included synthetic rubber to give it high-impact strength was being used in the production of 50% hydrochloric acid. Suddenly it was discovered that the acid was eating away the rubber—leaving black particles in the solution.

So out came the old pipe, replaced by Ryertex®-Omicron PVC—the pipe that's unplasticized, unmodified, and has no additives. There is *nothing* in the material to contaminate the acid. And it has *natural*, high-impact strength. This chemical company now has ¾" through 1½" Ryertex-Omicron PVC pipe, with companion fittings and valves, operating at continuous temperatures of 125° F. at maximum pressures of 40 p.s.i.

After 18 months of problem-free service, the engineering director has standardized on Ryertex-Omicron PVC. He said, "Thanks to Ryerson's quality PVC, our sales indicate that we are producing a fine quality of hydrochloric acid for our customers."

GET THIS NEW BOOKLET

. . . for latest information on combating tough corrosion problems with Ryertex-Omicron PVC. Write Joseph T. Ryerson & Son., Inc. for your free copy today. We will gladly work with you on any problems you may encounter.

Typical applications

Tanks and tank linings, troughs, pipelines for liquids or gases, fumes systems, blowers, roof ventilator housings, chutes, filter plates, splash covers, neutralizing acid equipment, settling and scrubbing towers—and many others.

INDUSTRIAL PLASTICS AND BEARINGS DIVISION

RYERSON STEEL®

Member of the INLAND Steel Family

STEEL • ALUMINUM • PLASTICS • METALWORKING MACHINERY

NATION'S MOST COMPLETE SERVICE CENTERS IN PRINCIPAL CITIES COAST TO COAST

For more information, turn to Reader Service card, circle No. 542

Propellants that are liquid at or near room temperature call for reevaluation of materials used for missile hardware. Here are the first quantitative data showing . . .

How the New Propellants Affect Plastics and Elastomers

by R. E. Mowers, *Research Engineer, Rocketdyne Div., North American Aviation, Inc.*

■ The graphs on the next two pages show quantitatively the effects of the new storable missile propellants on properties of usable elastomers and plastics.

Materials found by initial screening to be usable in fuels are: 1) fluorocarbon plastics, 2) Type III polyethylene, 3) nylon, and 4) certain types of butyl rubbers.

Materials found to be usable in the oxidizer are: 1) TFE and FEP fluorocarbon plastics and 2) fluoro-silicone rubber.

Table 1 shows the materials found by initial screening to be entirely unusable for prolonged service.

The quantitative data shown here are new. Most data on effects of liquid propellants on nonmetallic materials are qualitative. They tell whether a material is incompatible or compatible with the liquids, but they do not indicate to what extent the properties of so-called compatible materials are affected.

The new data on effects of fuels are based on tests using hydrazine, UDMH (unsaturated dimethyl hydrazine) and a 50:50 mixture of the two. The oxidizer used was NTO (nitrogen tetroxide). Such storable systems have good overall propellant characteristics, and can be substituted for the older cryogenic liquid oxygen-kerosene propellants in the same hardware configurations. Performance of the two types of systems is quite similar.

Tests were carried out under static conditions, using standard ASTM specimens and testing procedures.

Effects of fuels . . .

In general, hydrazine, UDMH and 50:50 mixtures of the two have less effect on plastics and elastomers than does the oxidizer. Also, the fuels have less effect on plastics (usually polymers consisting of only one basic polymer chain) than on elastomers (usually copolymers compounded with plasticizers, fillers and vulcanizing agents).

On plastics—Of the plastics tested, CFE fluorocarbon (chlorotrifluoroethylene, .e.g., Kel-F), TFE fluorocarbon (tetrafluoroethylene, i.e., Teflon), FEP fluorocarbon (fluorinated ethylene propylene, i.e., Teflon 100X), Type III (higher density) polyethylene and nylon were found to be essentially unaffected by two months exposure in hydrazine, UDMH or mixtures of the two. Properties of these materials, as shown in Table 2, remained about the same.

CFE fluorocarbon resin is the most desirable material for lip seals, as it is stronger than the other fluorocarbons, yet has greater resilience than nylon. In spite of the excellent resistance of CFE fluorocarbon indicated by the tests, many lip seals removed from disassembled valves after actual service in hydrazine fuels have shown radial cracks around the whole circumference of the seal. Such failures are believed to be caused by stress crazing of the material, brought about by the combination of internal stresses in the molded seal and exposure to the fuel. Further tests are now being carried out to confirm this theory.

An approach which may avoid this problem is to fabricate seals by postforming from sheet stock. Parts then are stress relieved prior to machining to final dimension. In comparison with molded

***Storable propellants** are replacing cryogenic propellants for "ready" missiles. Photo shows static firing test.*

EFFECTS OF FUELS

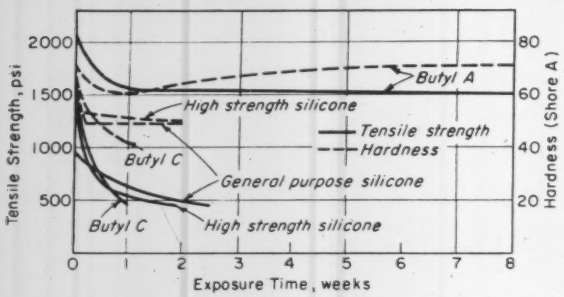


Fig 1—*Tensile strength and hardness vs exposure time in 50:50 UDMH and hydrazine.*

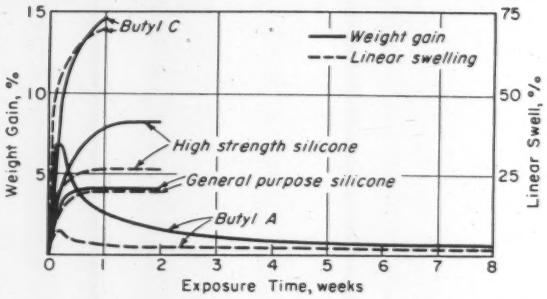


Fig 2—*Weight gain and linear swelling vs exposure time in 50:50 UDMH and hydrazine.*

seals, such seals have greater dimensional stability with fewer and lower residual stresses.

On elastomers — In general UDMH has a more severe effect on elastomers than hydrazine. Data here are for a 50:50 mixture of the two fuels.

The most resistant elastomers tested were two butyl rubbers (IIR) represented by the "Butyl A" curves in Fig 1 and 2. As shown in Fig 1, after a reduction of about 20% in tensile strength during the first two days, strength is little affected by exposure for the remainder of two months. Hardness, as shown by the dashed curve in Fig 1, increases gradually as plasticizer is leached out of the compound. The leaching of plasticizer is also reflected in the change in weight, shown in Fig 2. The initial increase in weight shown is due to absorption of fluid.

The curves labeled "Butyl C" in Fig 1 and 2 represent the behavior of two other butyl compounds, and indicate that all butyls do not perform equally well.

Most silicone rubbers tested were so plasticized by the fuels after about two days exposure that they had lost all resilience. (Oddly enough, *fluoro*-silicone rubber does not merely lose resilience but disintegrates in hydrazine-type fuels.) Comparative curves are given in Fig 1 and 2 for both a general purpose and a high strength silicone rubber. Silicone rubbers, even high strength types, are initially weaker than other elastomers. Thus the 30% further reduction in tensile strength caused by exposure results in tensile strengths which are substantially lower than those of the two good butyl rubbers after exposure.

TABLE 1—MATERIALS UNSUITABLE FOR USE WITH . . .

HYDRAZINE-TYPE FUELS		NITROGEN TETROXIDE OXIDIZER	
Material ↓	Type of Attack	Material ↓	Type of Attack
PLASTICS			
Mylar[a]	Brittle above 130 F	Nylon (6/6)	Dissolves
Polyvinyl Alcohol	Dissolves	Mylar[a]	Embrittles, blisters
Polyvinyl Chloride	Dissolves	Irradiated Polyethylene	Embrittles after prolonged exposure
Modified Polystyrene[b]	Disintegrates	Polypropylene	Embrittles after prolonged exposure
Polyester-Glass Laminates	Disintegrates	Glass-Reinforced Laminates	Dissolves various resins
ELASTOMERS			
Nitrile (NBR)	Softens, swells, gummy	Nitrile (NBR)	Dissolves
Neoprene (CR)	Blisters, swells	Neoprene (CR)	Blisters, dissolves
Silicone[c]	Softens, loses properties	Hypalon[f]	Swells excessively
Polysulfide	Disintegrates	Butyl (IIR)	Disintegrates
Fluoro-Silicone	Dissolves	Silicone[c]	Hardens, disintegrates
Viton A[d]	Embrittles, flakes	Viton A[d]	Swells excessively
Kel-F Elastomer[e]	Blisters, becomes tacky	Kel-F Elastomer[e]	Swells, becomes tacky

[a]Du Pont's polyester film. [b]Styrene-butadiene type. [c]General purpose and high strength types.
[d]Du Pont's fluoroelastomer; copolymer of vinylidene fluoride and perfluoropropylene.
[e]Minnesota Mining's fluoroelastomer; copolymer of chlorotrifluoroethylene and vinylidene fluoride.
[f]Du Pont's chlorosulfonated polyethylene.

TABLE 2—PROPERTIES OF PLASTICS UNAFFECTED BY HYDRAZINE-TYPE FUELS

Plastic →		Fluorocarbons			Type III Polyethylene	Nylon[d]
	ASTM	CFE[a]	TFE[b]	FEP[c]		
Tensile Strength, 1000 psi	D638	4.6-5.7	1.5-3.0	2.7	4.4	8.6-11.2
Elongation, %	D638	125	100-200	250-330	40-400[e]	200-300
Mod of Elast in Flex, 10^5 psi	D790	1.8	1.4	1.6	1.4	1.8
Izod Impact Str, ft-lb/in. notch	D256	3.6	2.3	—	3.0	2.0
Hardness (Shore)	D676	D80	D50-60	D55	D68	—
Heat Dist Temp (66 psi), F	D648	—	250	162	165-175	360-390

[a]Minnesota Mining & Mfg. Co.'s Kel-F. [b]Du Pont's Teflon. [c]Du Pont's Teflon 100X.
[d]Values are for type 6/6 at equilibrium moisture content in air. [e]Varies radically with strain rate.

Effects of oxidizer . . .

On plastics—TFE and FEP fluorocarbons are the only plastics

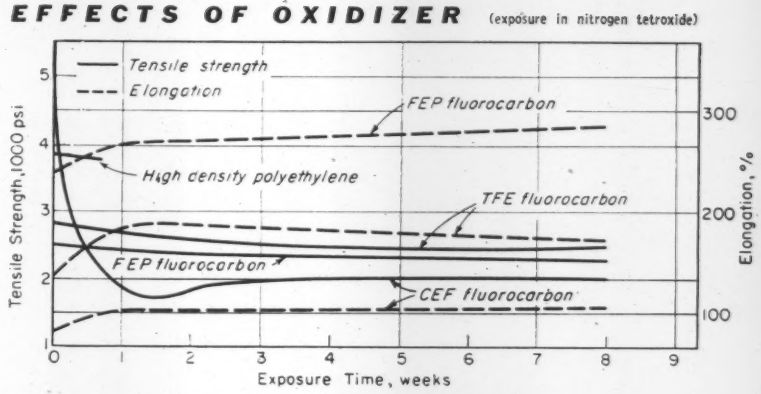


Fig 3—*Tensile strength and elongation of plastics.*

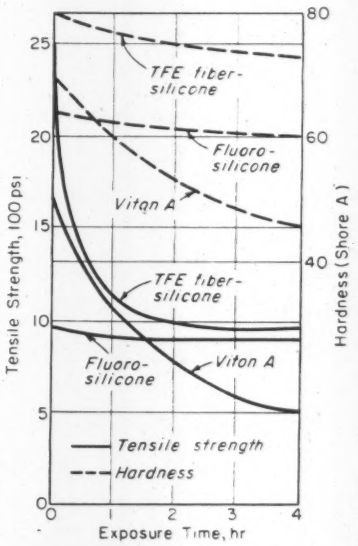


Fig 4—*Tensile strength and hardness of elastomers.*

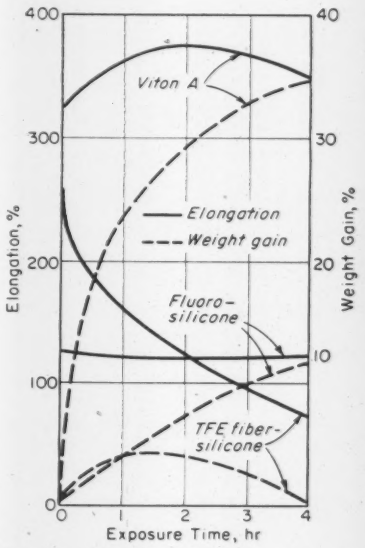


Fig 5—*Elongation and weight gain of elastomers.*

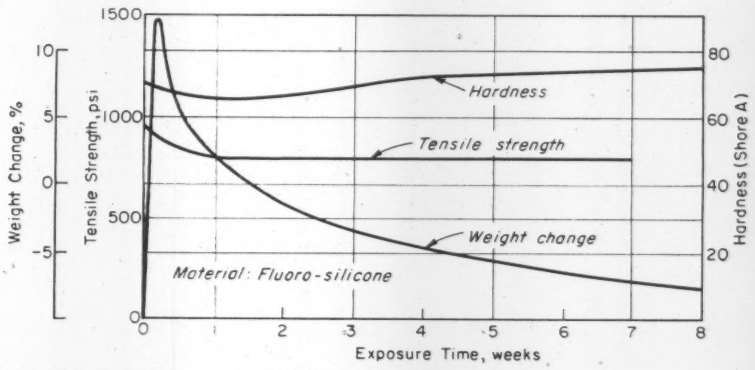


Fig 6—*Tensile strength and hardness of fluoro-silicone rubber.*

found suitable for prolonged use in NTO. Although CFE fluorocarbon has the best initial combination of tensile strength, flexural modulus and impact strength, exposure has a drastic effect on tensile strength (see Fig 3). Tensile strength drops from 5500 to 3500 psi in just 4 hr exposure. In less than one week, CFE loses 60% of initial tensile strength and an estimated 90% of initial flexural modulus.

TFE and FEP fluorocarbons are essentially unaffected. Because of their lower initial strengths, thicker seals must be used when replacing CFE seals. Of the TFE and FEP fluorocarbon materials, FEP is recommended because it can be postformed at lower temperatures than TFE, and its greater translucence makes flaws easier to detect.

Early reports listed polyethylene as suitable for prolonged use in NTO. A Type III polyethylene was evaluated, and found to be completely unaffected by exposures up to three days. However, after one months exposure, specimens were completely disintegrated, leaving a white powder residue.

Other plastics yet to be evaluated are polypropylene and irradiated polyethylene.

On elastomers—Most elastomers are completely disintegrated by NTO in a few hours. Fluorosilicone rubber is the only elastomer not grossly affected by short-time exposure, as shown in Fig 4 and 5.

Fig 6 gives the only data available on effects of prolonged exposure. Although the fluoro-silicone does not have optimum physical properties for an elastomer, it is the only elastomer tested that is usable after two months exposure. Initial tensile strength of 950 psi is reduced to 800 psi after the first hour of exposure, but gradually levels off until after the first week's exposure there is little subsequent deterioration.

The silicone rubber reinforced with TFE-fluorocarbon fiber would probably be satisfactory as a static seal in NTO service. The compound does not swell to an appreciable degree, but it does tend to delaminate, the bond between TFE fiber and the elastomer being attacked by the oxidizer.

***Drawn luggage shell** is removed from press.*

Formed Magnesium Parts Can Keep Rolled Strength

Rapid drawing at lower-than-normal temperatures prevents annealing.

by Willard G. Axtell, *Chief Engineer, Shwayder Bros., Inc.*

■ Magnesium alloy parts can be formed at moderate temperatures —about 350 F—at rates fast enough to prevent softening. Parts formed in this manner retain the strength of as-rolled material. Generally magnesium alloys are worked at temperatures above 400 F.

Usefulness of the new process depends on the depth and intricacy of the contour to be formed. It is useful only for relatively shallow, simple shapes such as squares, rounds and rectangles. It is estimated that the depth of draw could be as much as two diameters for round sections and twice the shortest dimension for rectangles. Straight-sided shapes should have generously rounded corners, although no formula for minimum bend angles has been developed.

A successful application of the technique is the drawing of shells for magnesium luggage.

Effect of forming conditions

Working magnesium at elevated temperatures is necessary because the metal's hexagonal close-packed structure is less ductile than the face-centered cubic structure common to many of the other nonferrous metals, such as aluminum. When formed in the usual temperature range, however, the rolled material softens quite rapidly, and the resulting loss in strength can be detrimental in some uses.

The degree of softening that results when magnesium is heated depends not only on the temperature but also on the time of exposure. Effects of temperature and time on the tensile and yield strengths of several magnesium alloys are shown in Fig 1 and 2. It is not believed that properties such as corrosion resistance are affected. Compositions of the alloys are given in a table.

The graphs show that short time and low temperature treatments result in greater retention of the original properties than either higher temperatures or increased time of exposure. At the lowest temperatures, there is little loss in strength even for exposures of 60 sec; at temperatures over 400 F most of the alloys are seriously affected by exposure as short as 20 sec.

These strength determinations were made on sheet material, but served as a definite guide to the selection of suitable forming temperatures. Sheet thickness is probably not a factor. The aim was to select the highest possible temperature that would result in retaining most of the original strength of the material. Thus, the 340 to 360 F range was selected for forming.

Why magnesium was selected for luggage

Materials used in luggage must:

1. Be light in weight.
2. Have the highest possible resistance to denting and shock.
3. Be formable into a fashion-acceptable shape without loss of strength.
4. Be processable at reasonable cost.

Magnesium was selected because of its light weight (only ⅝ that of aluminum) and its high damping capacity. The damping property is responsible for the magnesium's ability to absorb shock and resist travel damage.

Having determined that magnesium offered many of the desired properties, we made tests to

COMPOSITION AND PROPERTIES OF ALLOYS USED

Alloy	Condition	Nominal Composition, %			Tensile Strength, 1000 psi	Yield Strength, 1000 psi
		Zn	Al	Rare Earths		
AZ31B	As Rolled	1.0	3.0	—	42.2	32.5
ZE-10	As Rolled	0.5	1.5	—	39.4	28.8
ZE-10	Pickled[a]	0.5	1.5	—	41.7	31.2
ZM-10	As Rolled	1.25	—	0.16	36.8	27.6

[a]Acetic-nitric pickle.

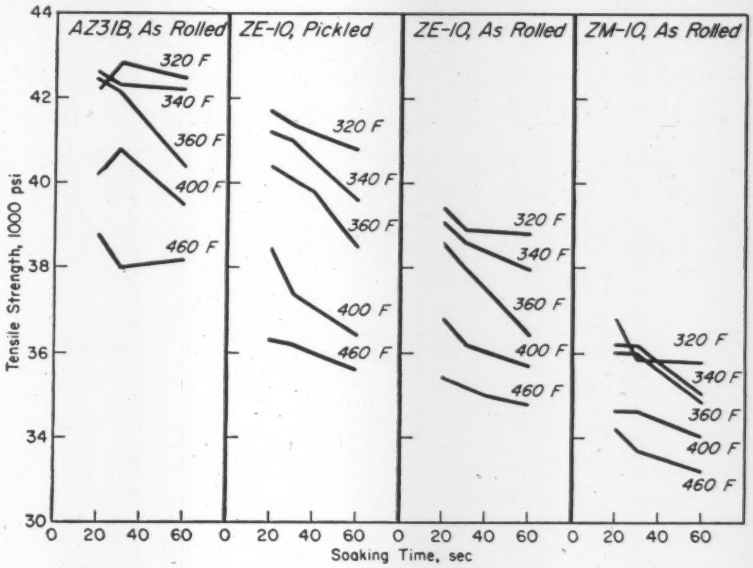


Fig 1—*Tensile strength: effect of time and temperature.*

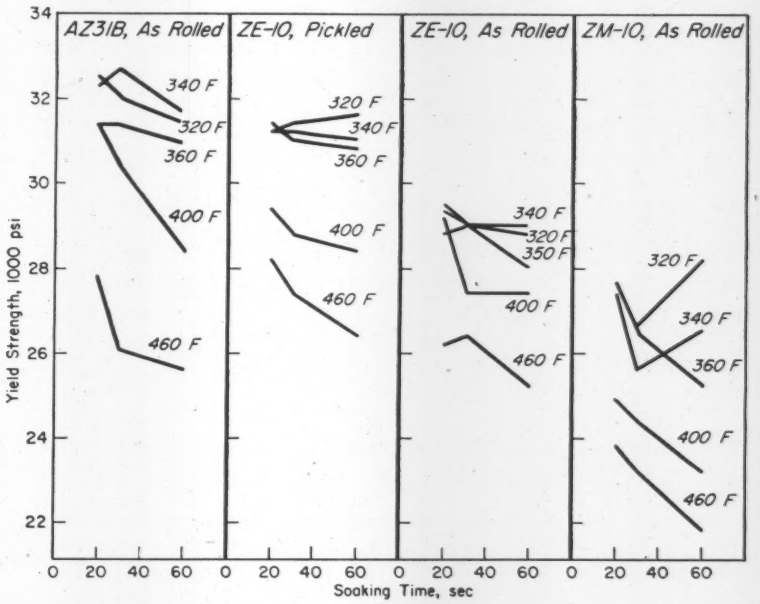


Fig 2—*Yield strength: effect of time and temperature.*

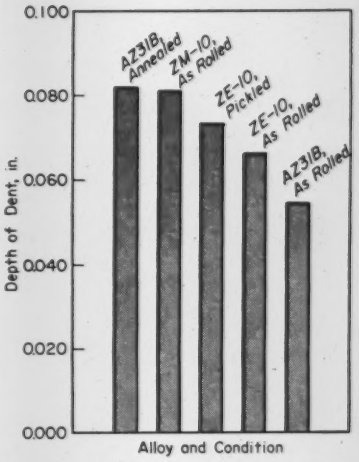


Fig 3—*Resistance to denting of several magnesium alloys.*

Steps in Warm Drawing

1. Sheets are heated to 180 F, passed through a coater where a dry film lubricant is applied, and dried at about 180 F. Coating and drying require about 5 min.

2. Coated sheet is placed in the press which closes and dwells for about 5 sec, during which time the sheet is heated to the 340-360 F range.

3. After the 5-sec dwell, drawing proceeds at the rate of 1 fpm and the press dwells for 11 sec at the end of the draw.

4. Drawn shells are stacked to obtain slow cooling and reduce springback when flange is removed.

5. Shell flanges are pinched off in a mechanical press.

determine the dent resistance of several alloys by use of a 28-in-lb blow on an anvil having a radius of 0.313 in. Inspection of the values shown in Fig 3 in comparison with the strength values given in Fig 1 and 2 shows that although dent resistance is not directly proportional to strength, there are considerable differences among the materials. Particularly noteworthy are the differences between AZ31B in the as-rolled and the annealed conditions. Dents in the annealed material are 1½ times as deep as those in the as-rolled sheet. These results point to the desirability of forming without softening.

Forming the shell

Steps in forming the luggage shell are listed in an accompanying box. Hydraulic presses of 150 to 200-ton capacity are used; the pressures vary with the size and depth of the shell but are approximately 50 tsi on the hold-down ring and 50 tsi on the pad.

Elapsed time from start of coating to finish drawing is 55 sec for a shell requiring a 6-in. draw completed in a single stroke; shallower shells are produced in 35 to 40 sec. The shell is finished by cladding it with a 0.015-in. sheet of vinyl plastic.

Chlorinated polyether • Glass-polyester laminates • Epoxies • High-build coatings • Plastics pipe • Refractories • Titanium and zirconium . . . These materials offer

New Ways to Combat Corrosion

Data and case histories based on papers given at the most recent conference of the National Association of Corrosion Engineers.

by Robert J. Fabian, *Associate Editor, Materials in Design Engineering*

Glass-polyester laminates are now being used in a wider range of chemical, petroleum and allied equipment requiring resistance to chemicals and weathering (see photos).

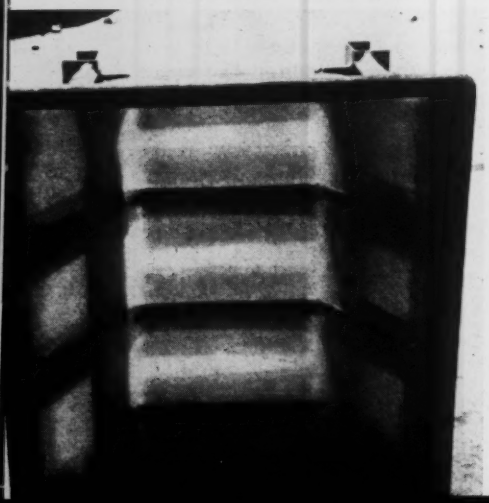
Glass-polyester laminates have proved themselves in many applications where high strength and light weight coupled with corrosion resistance is required. The wide experience gained with the materials for chemical and petroleum equipment shows an impressive array of successes and some notable failures. Experience points out the need for selection of the proper polyester and for using glass-polyester laminates only where they are best suited. Corrosion engineers now realize that "glass-polyester" denotes a family of materials with widely differing properties and do not condemn all glass-polyester materials because one has failed in service.

In general, the available glass-polyester materials can be divided into five broad categories as follows:

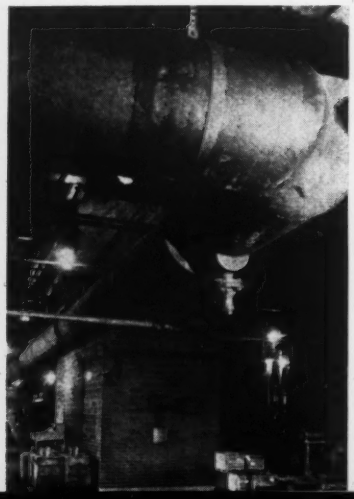
1. High chemical resistant.
2. Medium chemical resistant.
3. Standard chemical resistant.
4. Food grade, solvent resistant.
5. Fire resistant, chemical resistant.

Many data are available on the ability of different polyesters to resist attack by specific chemicals. Since a glass-polyester structure is more rapidly attacked when it is highly stressed, mechanical design is also important. Experience shows that a maximum safety factors of 5—as high as 12 or 15 under very severe and corrosive conditions—is required for a long and satisfactory life.

Press box *of steel-reinforced glass-polyester laminate handles sulfuric acid dye cake at temperatures up to 180 F. After two years, condition of 4 x 4 ft boxes varies from excellent to charred, the charred condition occurring when sulfuric acid concentrations run above 90%.*

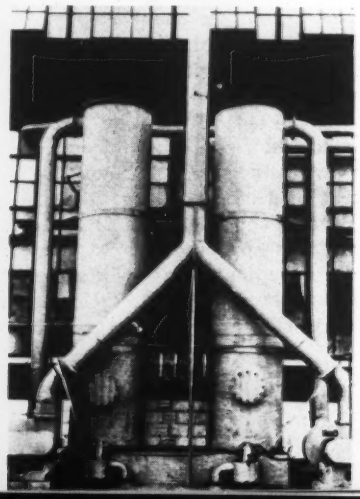


Ductwork *is in excellent condition and shows no sign of failure after five years of conducting vapors from an oleum quench containing 30% sulfuric acid. The 2-ft glass-polyester ductwork lasts considerably longer than previously used monel* ***ductwork.***



Photos Haveg Industries, Inc.

Fume scrubbers *have resisted hydrochloric and ammonia fumes for almost three years with no sign of attack. Each glass-polyester unit is 3½ ft in dia by 16 ft high.*



Chlorinated polyether

parts and coatings are providing high resistance to water, chemicals and abrasion for valves, tees, water meters and other parts (see photos).

Outstanding characteristics of chlorinated polyether resin (Penton) include its ability to withstand boiling water, its extremely low water absorption, and its exceptional chemical resistance. These properties, as well as good mechanical properties and easy formability, have resulted in a number of successful new applications.

A plot of the operating pressures for a solid chlorinated polyether valve shows a very flat slope (Fig 1), almost to the material's melting point. Thus, the material can be used in practical wall thicknesses at temperatures of 250 to 300 F. In addition, high temperature creep tests (see Fig 2) show that the material has good dimensional stability for low design stress levels in chemical processing equipment.

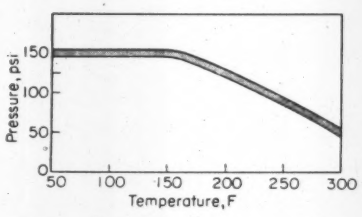


***Fig 1**—Operating pressure-temperature rating of chlorinated polyether valves.*

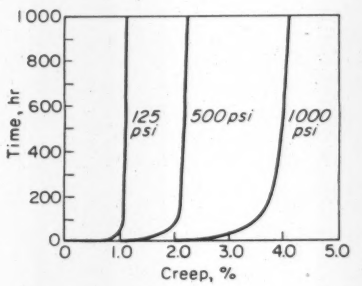
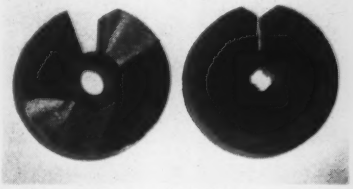


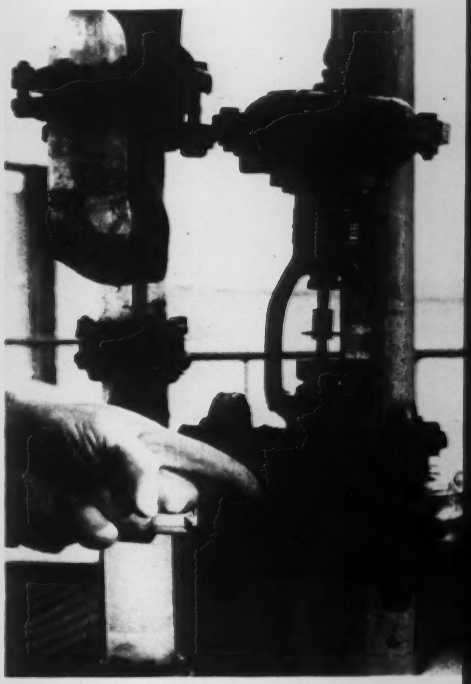
***Fig 2**—Creep of chlorinated polyether for various loads at 280 F.*

Photos Hercules Powder Co.

***Steel flanged tee** is one of the first successful applications for chlorinated polyether coatings applied by fluidized bed process. Tee (coated inside and out) was used in mixture of weak acetic acid and ethyl acetate at 86 F. Interior coating remained in good condition after two years but tee had to be removed when mechanical abuse ruptured external coating.*



***Wobble plate** for hot water meter must have high water resistance, dimensional stability and abrasion resistance. Graphite-filled chlorinated polyether was selected for part after unsuccessful tests with 50 other materials.*



***Control valve** made of chlorinated polyether has been successfully used in a 32% hydrochloric acid by-product control system for seven months. Application is particularly severe, as off gas from a chlorination system contains a small amount of chlorine gas which is absorbed along with hydrochloric acid ahead of control valve.*

Plastics pipe

is now being used in many marine applications because of its excellent resistance to salt water and other corrosives.

Plastics pipe is now accepted by U. S. Coast Guard and American Bureau of Shipping in most vessels for such applications as: overflows, air escapes, sanitary and compressed air piping, drains, potable water systems, salt water piping and many others.

Of the many pipe materials available, the two rigid materials receiving the most attention are ABS plastics and unplasticized PVC. ABS pipe is recommended over PVC pipe because of its higher resistance to impact, vibration and staining. However, in contrast to PVC pipe, ABS pipe is self-extinguishing (not non-inflammable) and consequently should not be used in critical fire areas. Also, it should be understood that both materials are thermoplastic, and hot spots will cause them to soften.

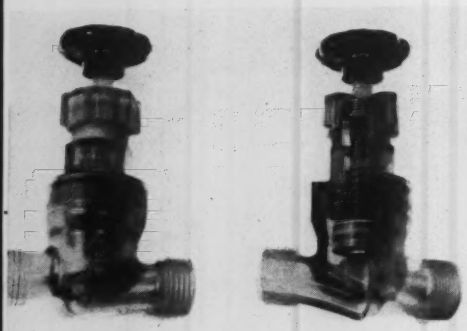
Following are some recommendations for using plastics pipe in marine applications:

Joining—PVC and ABS pipe can be joined using threaded fittings, solvent welded slip fittings, insert fittings, bell sections or mechanical couplings. However, for quick assembly and disassembly the designer should consider the use of threaded

fittings and heavy wall pipe (Schedule 80).

A non-hardening pipe dope with a plastics base is recommended to minimize leaking, chattering and galling of pipe joints. It is best to use flanged joints when joining plastics pipe to existing metal lines. Soft rubber flanges should be used between the flanges.

Forming and bending — The thermal coefficient of expansion of some plastics pipe is about 13 times that of steel. Thus, plastics pipe can expand or contract about 6 in. per 100 ft of length for every 50 °F change in temperature. The best way to allow for this change is to incorporate U-bends of the same shape as (but larger than) iron pipe. Ends should be free, and supporting members should not be so tight as to anchor the pipe.



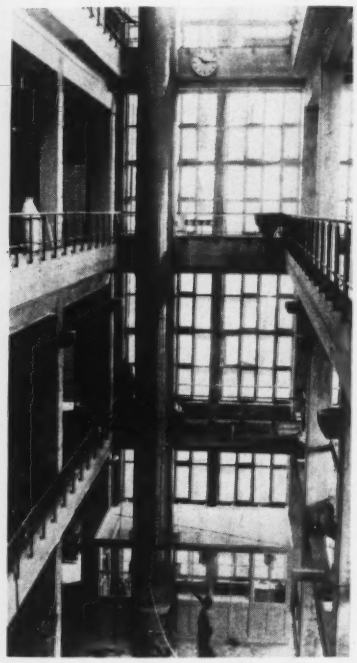
Cast valve *made from an epoxy resin-anhydride system can be used at pressures up to 90 psi. Threads shown in cutaway view are cut after valve body is cast.*

Photos Ciba Products Corp.

TABLE 1—CHEMICAL RESIGNATION OF TWO EPOXY SYSTEMS
(% Weight Increase After Immersion)

Chemical ↓	Ciba 502 + TET[a] Hardener (3 months)[c]	Ciba 6060 + PA[b] Hardener (12 months)[c]
Acetic Acid, 5%	—	0.9
Ammonia, 10%	1.2	0.9
Butyl Alcohol, 100%	0.9	—
Carbon Tetrachloride, 100%	7.9	—
Caustic Solution, 10%	1.1	0.8
Ethyl Alcohol, 95%	9.0	1.5
Gasoline	0.003	—
Hydrochloric Acid, 10%	2.2	0.7
Hydrogen Peroxide, 30%	13.0	—
Hydrogen Peroxide, 3%	—	0.9
Nitric Acid, 10%	2.7	−0.8
Sodium Chloride, 10%	1.1	0.7
Sulfuric Acid, 30%	—	0.6
Sulfuric Acid, 50%	2.6	—
Triethanolamine	−0.01	—

[a]Triethylene tetramine (cold liquid system).
[b]Phthalic anhydride (hot melt system).
[c]Immersion time.



Exhaust stack *made of glass-epoxy laminate has high resistance to corrosive flue gases. Stack is 50 ft high by 40 in. in dia and consists of two concentric tubes ⅛ in. thick separated by ⅜-in. layer of polyurethane foam.*

Epoxy

resin structures appear promising where high mechanical strength and resistance to special chemicals are required (see photos).

As with mechanical properties, the chemical resistance of epoxies depends on the resin-hardener system used. This is evident from the data in Tables 1 and 2. Anhydride-cured hot melt systems such as the one described in Table 1 are often preferred for long-term resistance to many chemicals. Where handling requirements dictate the use of a cold liquid system, the aromatic amines such as triethylene tetramine, m-phenylene diamine and methylene dianiline are preferred for resistance to acids and caustics.

The properties shown in the tables can be altered by variations in curing procedure. In general, a higher cure temperature tends to increase flexural deformation temperatures and resistance to heat aging. Slower cures at moderate temperatures tend to produce lower shrinkage during cure and somewhat higher impact resistance.

TABLE 2—CHEMICAL RESISTANCE OF TWO GLASS-EPOXY LAMINATES[a]

Chemical ↓	Ciba 6005 + Modified Liquid Eutectic Hardener		Ciba 6020 + HET Anhydride Hardener	
	Weight Increase, %	Flex Str Retained, %	Weight Increase, %	Flex Str Retained, %
Acetic Acid, 5%	0.3	9	0.2	100
Distilled Water	0.3	96	0.3	91
Ethylene Glycol[b]	0.1	97	—	—
Hydraulic Oil[c]	0.1	98	—	—
Hydrocarbon Test Fluid[d]	0.1	99	0.1	98
Hydrochloric Acid, 10%	0.1	86	−3.6	49
Hydrogen Peroxide, 3%	0.3	94	0.2	33
Nitric Acid, 10%	0.1	84	−0.1	41
Petrohol 99[e]	0.1	98	0.1	100
Sodium Chloride, 10%	0.3	96	—	—
Sulfuric Acid, 3%	0.05	88	−0.2	86

[a]Three months exposure. [b]MIL-E-5559. [c]MIL-O-5606. [d]MIL-H-3136. [e]MIL-F-5566.

Organic coatings

can now be applied in the field in heavy thicknesses with fewer coats. Immediate benefit has been lower equipment down-time.

The following coatings now offer easier application:

1. Hot spray vinyls.
2. Catalyst-cured phenolics and epoxies.
3. Catalyst-cured, epoxy-modified phenolics.
4. High-build alkyds.

Field tests show that these coatings can provide satisfactory protection on a wide range of oil refinery equipment such as waste water separators, tank interiors and exteriors, cooling tower fan assemblies and masonry walls (for other uses, see photos).

Hot spray vinyls—These coatings apparently eliminate a problem encountered with conventional vinyls: the need for multiple coats to prevent pinholing. Although hot spray vinyls are limited by the occurrence of blisters at operating temperatures above 150 F, indications are that the coatings provide good protection on alternating wet and dry surfaces. Such surfaces include piping adjacent to cooling towers and waste separators at temperatures below 150 F. An added benefit of the coatings in refinery applications is their resistance to acid and alkali attack.

Catalyst-cured phenolics and epoxies—A new development in phenolic coatings has been the introduction of coatings which cure through the use of a liquid catalyst and do not have to be baked. These coatings permit multiple-pass application to a thickness of 12 mils per coat without runs or sags. They are now being used to protect oil refinery exchanger channels and heads.

Also available now are catalyst-cured epoxy coatings that contain no volatile materials, consisting entirely of film-forming material. The coatings have been used to prevent "weepage" of chemical solutions at riveted tank seams.

Catalyst-cured, epoxy-modified phenolics—Thick films of these coatings are now being used to protect:

1. Surfaces exposed to low concentrations of sulfuric acid.
2. Tank interiors against propane and other light hydrocarbons.
3. Vessels exposed to water.
4. Steam condensate tanks with condensate temperatures of about 180 F.
5. Water cooling tower fan assemblies exposed to warm, humid atmospheres.
6. Tank car interiors (preventing contamination of highly refined oils).

The coatings show good resistance to high concentrations of caustic soda and to solutions of oils and caustic soda at temperatures up to 200 F and higher.

High-build alkyds—When carefully applied in multiple passes, one 4-mil coat of this type of coating has proved to be as satisfactory as two coats of a conventional alkyd. A thickness greater than 4 mils can produce "mud cracking" after a year of exposure. However, satisfactory one-coat application of high-build alkyd red lead primers has been obtained on vertical surfaces at dry film thicknesses as great as 6 to 8 mils.

Water circulation pipe line *is normally protected with bituminous coating. However, indications are that thick film hot spray vinyl coating may provide longer protection. Service is severe as pipe is exposed to warm, humid water spray.*

Oil refinery exchanger channel *is protected for at least two years by using an 8 to 9-mil thick, catalyst-cured phenolic coating.*

Photos Gulf Oil Corp.

Refractories

are valuable as substitutes for metals and other materials where high corrosion resistance coupled with resistance to abrasion, erosion and heat is needed.

Special refractories are now being used in many applications requiring resistance to various types of corrosion:

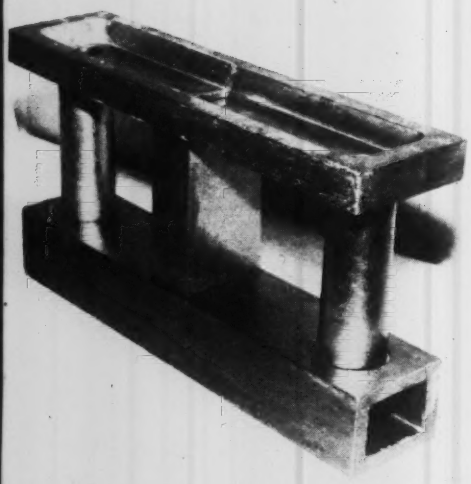
Corrosion by gases—Silicon nitride-bonded silicon carbide has proved successful for the high temperature steam orifices in catalytic crackers. The orifices (see photo) show little wear after a year's service, as compared to previously used stainless steel orifices which lasted two to four months.

Ceramic-bonded silicon carbide is providing exceptional resistance against sulfur dioxide and trioxide gases at high temperatures. Typical applications include spray nozzles, dampers, and linings for flues and ducts. Inner liners of

Steam orifices *made from nitride-bonded silicon carbide are shown before (left) and after (right) 1 yr of use in catalytic cracking operation. Previously used stainless steel orifice (top) failed after less than four months.*

Photos Carborundum Co.

this material are also being used to extend the life of nickel tubes carrying a mixture of chlorine gas, chlorinated hydrocarbons and hydrochloric acid at 1100 F.



***Induction furnace parts** of nitride-bonded silicon carbide effectively resist effects of aluminum oxide dissolved in molten cryolite.*

Because of their lack of free silica, pure alumina refractories are unaffected by nascent or atomic hydrogen (nascent hydrogen is extremely corrosive and reacts readily with iron or silica in any form). These refractories are being successfully used in synthetic gas generator linings, tungsten carbide furnace mufflers, and gas-reformer checkerwork.

Corrosion by molten slags and salts—A fused-cast, beta alumina refractory has proved effective at the metal line in an electrolytic cell producing magnesium metal from molten magnesium chloride. In a similar application involving an aluminum reduction cell (aluminum oxide dissolved in an electrolyte of molten cryolite) a nitride-bonded and a ceramic-bonded silicon carbide material proved most effective (see photo). The fused-cast refractories and most other ceramics are unusually susceptible to molten cryolite.

Fused-cast alumina refractories can also be used to resist the cutting action of slag in synthetic gas generators handling pulverized coal, steam and oxygen. The refractories are also widely used as linings for glass furnaces, sodium silicate tanks, and rock wool reverberatory furnaces where exceptionally severe corrosion conditions exist.

Corrosion by acids—The high acid resistance of refractories is being demonstrated in a number of applications. Among the successful uses for ceramic-bonded silicon carbide are:

1. Linings for water-cooled hydrogen chloride burners.
2. Domes in decomposers handling alkalation sludges.
3. Radiating domes and rabble blades in multiple hearth roasters.
4. Hydrochloric acid furnace domes.
5. Wire grids and sinkers in pickling lines.

Other successful refractories and their applications include: nitride-bonded silicon carbide for acid slurry pump parts; ceramic-bonded silicon carbide for valves and dampers in sulfuric acid gas lines; and fused-cast refractories for Weir blocks in pickling tanks.

Titanium and zirconium

are showing excellent resistance to many chemicals. In some cases the resulting length of service more than compensates for the high materials cost.

Titanium's excellent resistance to a wide variety of corrosive media is well known, and recent tests show that the metal is particularly outstanding in:

1. Wet chlorine gas under all conditions up to 205 F.
2. Solutions containing chlorine.
3. Hydrochlorous acid and hypochlorites.
4. Nitric acid from 35 to 65% up to 265 F.
5. Calcium chloride up to 55% and up to 235 F.
6. Atmospheres containing chlorine and hydrochloric acid.

Zirconium has also shown excellent resistance to a number of test corrosives such as:

1. Hydrochloric acid up to 36%.
2. Dry chlorine.
3. Sodium hydroxides in all concentrations up to 73% and up to 280 F.
4. Nitric acid in all concentrations up to 65% and up to 265 F.
5. Calcium chloride solutions up to 55% and up to 235 F.

Because of titanium's outstanding resistance to some media the metal is now being evaluated for equipment such as valves, heating coils and nitric acid reboilers. Likewise, zirconium is being used as valve stems in control valves with dry chlorine and strong hydrochloric acid. Such equipment has been in satisfactory service for six months or more, thus bearing out test results.

Corrosion evaluation of titanium and zirconium has produced some surprising data. The performance of titanium and zirconium in boiling 62 and 72% calcium chloride is surprising, particularly in the case of titanium which is reported to be resistant to 80% concentrations. Also, titanium's excellent resistance to sodium hydroxide solutions up to 73% is unexpected, mainly because previous data stopped at 40 to 50% concentration. In sulfuric acid containing chlorine, titanium was found to be resistant to concentrations up to 72%, whereas zirconium is adversely affected by the same media below 60% concentration.

References

The information in this article is based on material presented in the following papers delivered at the 15th Annual Conference of the National Association of Corrosion Engineers, Mar '59, Chicago.

Chlorinated polyether: "Combatting Corrosion with Penton—Chlorinated Polyether," C. S. Miller, J. B. Martin.

Glass-polyester laminates: "Polyester Fiber Glass Equipment: Case Histories of Their Use in the Chemical, Petroleum and Allied Industries," Barnett, T. F. Anderson.

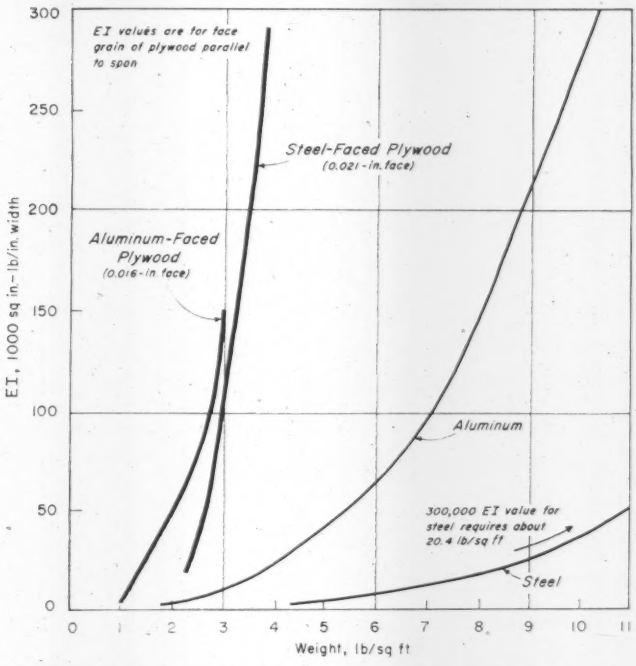
Epoxies: "Epoxy Resin Structures in Corrosion Resistant Applications," E. N. Dorman, W. Ibsen.

Organic coatings: "Oil Refinery Applications of Thick-Film Synthetic Coatings," R. W. Maier, W. B. Cook, R. B. MacQueen.

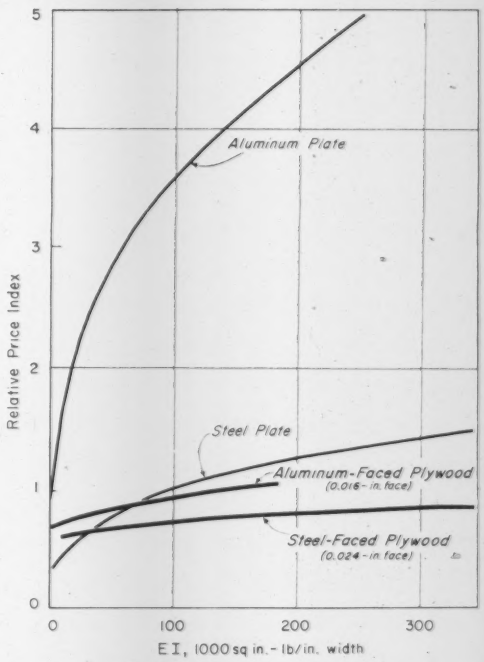
Plastics pipe: "Controlling Marine Corrosion with Rubber and Plastics," J. A. Thompsen.

Refractories: "Corrosion-Resistant Special Refractories—Their Applications and Potentialities," R. W. Brown, H. G. Noble.

Titanium and zirconium: "The Corrosion Resistance of Titanium and Zirconium in Chemical Plant Exposures," P. J. Gegner, W. L. Wilson.



***Rigidity vs weight**—Startling increases in rigidity per unit weight are gained by using laminates.*



***Cost vs rigidity**—Cost is reasonable compared with flat aluminum (50¢/lb) and steel (7¢/lb).*

These graphs show the advantages of

Metal-Faced Plywood: Light but Rigid

Don't overlook these older sandwich materials. Here are design data . . . current uses.

by G. E. Kloote, *Chief Engineer*
Haskelite Mfg. Corp.

■ In many cases two materials are better than one. Bond a metal facing to one or both sides of laminated plywood and you get the substantial increases in flexural rigidity shown graphically in the curves above left. The curves at right compare costs of such laminates with those of aluminum and steel plate. This qualitative comparison is only applicable where flat sheets are used with no rolled or fabricated stiffening members. Some typical examples of benefits gained:

1. At a given weight of 2.5 lb per sq ft, a ⅜-in. laminate of steel facings on both sides of plywood provides 75 times the resistance to bending of a comparable weight (16-gage or 0.063-in.) of steel.

2. A ⅜-in. laminate with aluminum facings on both sides of plywood weighs 1.43 lb per sq ft, but has 100 times the stiffness of 20-gage (0.038-in.) steel which weighs 1.5 lb per sq ft.

3. A ¼-in. laminate faced on both sides with zinc-coated steel has about the same stiffness as 6-gage (0.20-in.) steel, yet weighs only one fourth as much.

Table 1 shows rigidity values and corresponding weight for both steel and aluminum-faced laminates at different thicknesses. Tables 2 and 3 show deflection under load and ultimate load for materials faced with aluminum and steel.

Combinations available

Virtually any combination of metal and plywood can be produced. Probably the most widely used metals are 24 to 26-gage (0.025 to 0.019-in.) stainless or

TABLE 1—STIFFNESS AND WEIGHT OF PLYWOOD-METAL LAMINATES[a]

Plywood Thickness, in.	No. of Plies	EA, 1000 lb/in. width[b]		EI, 1000 sq in.-lb/in. width[c]		Bending Moment (max), in.-lb/in. width		Weight, lb/sq ft
		Long.	Trans	Long.	Trans	Long.	Trans	
STEEL (0.024-in.) BOTH SIDES								
¼	3	1671	1628	28.9	27.3	388	366	2.79
⅜	3	1755	1755	63.8	58.8	604	556	3.13
⅜	5	1786	1724	62.7	59.9	596	566	3.13
½	5	1936	1784	112.5	104.8	822	765	3.53
⅝	5	2060	1870	175.1	163.8	1040	974	3.83
¾	5	2070	2070	249.7	239.6	1250	1200	4.23
¾	7	2070	2070	254.2	235.2	1270	1180	4.23
1	7	2185	2375	450.0	440.0	1720	1680	5.00
1⅛	7	2385	2385	594.1	579.2	2030	1975	5.35
ALUMINUM (0.016-in.) BOTH SIDES								
¼	3	551.6	508.8	7.7	6.0	131	103	1.25
⅜	3	635.0	635.0	18.4	13.4	217	158	1.58
⅜	5	666.6	603.2	17.4	14.5	205	171	1.58
½	5	816.0	664.0	34.2	26.6	308	240	1.98
⅝	5	940.0	750.0	56.1	44.7	410	327	2.28
¾	5	950.0	950.0	81.3	71.1	499	437	2.68
¾	7	950.0	950.0	85.7	66.6	527	409	2.68
1	7	1065.0	1255.0	158.4	148.2	738	690	3.46
1⅛	7	1265.0	1265.0	211.1	196.2	875	813	3.81

[a]Longitudinal and transverse refer to direction of plywood face grain with respect to span length.
[b]EA is modulus of elasticity times cross-sectional area. Must be considered in composite materials.
[c]EI values computed on following basis: E for fir plywood is 1.6×10^6 psi for long plies and 80×10^3 psi for transverse plies; ultimate fiber stress in bending for fir is 8000 psi; for steel, E is 30×10^6 psi and ultimate fiber stress in bending is 60,000 psi; for aluminum, E is 10×10^6 psi and ultimate fiber stress is 24,000 psi.

TABLE 2—ULTIMATE LOAD IN FLEXURE[a]
(Lb/Sq Ft at Failure for Simple Beam Loaded Uniformly)

Span, in. → Thk, in. ↓	12		24		36		48		60		72		84		96	
	Steel[b]	Al.	Steel[b]	Al.	Steel	Al.	Steel	Al.	Steel	Al.	Steel	Al.	Steel	Al.	Steel	Al.
¼ (3 ply)	1310	1048	655	262	345	117	194	65	124	42	86	29	63	21	48	16
⅜ (3 ply)	1910	1736	955	434	537	193	302	108	193	69	134	48	99	35	75	27
⅜ (5 ply)	1920	1642	960	411	529	182	298	102	190	66	132	46	97	33	74	26
½ (5 ply)	2530	2460[c]	1265	617	730	274	411	154	263	99	183	68	134	50	103	38
⅝ (5 ply)	3120	3040[c]	1560	820	925	364	520	205	333	131	231	91	170	67	130	51
¾ (5 ply)	3690	3580[c]	1845	998	1110	444	625	250	400	160	278	111	204	81	156	62
¾ (7 ply)	3660	3480[c]	1835	1053	1130	469	635	264	407	169	282	117	207	86	159	66
1 (7 ply)	4810	4630[c]	2405	1480	1530	657	861	370	551	236	383	164	281	121	215	92
1⅛ (7 ply)	5540	5070[c]	2770	1750	1807	777	1015	437	650	280	452	194	332	143	254	109

[a]Steel values are for panels with both sides faced with 0.024-in. steel; aluminum values are for panels with both sides faced with 0.016-in. aluminum; values for maximum stress in rolling shear for fir plywood taken to be 200 psi ultimate.
[b]Because of shortness of span, all these values are for failure in shear.
[c]Failure is in shear.

TABLE 3—DEFLECTION UNDER LOAD[a]
(Deflection in In. for Simple Beam with Uniformly Distributed 10-Lb/Sq Ft Load)

Span, in. → Thickness, in. ↓	12		24		36		48		60		72	
	Steel	Al.	Steel	Al.	Steel	Al.	Steel	Al.	Steel	Al.	Steel	Al.
¼ (3 ply)	0.00065	0.00245	0.01037	0.0392	0.0527	0.198	0.166	0.627	0.405	1.53	0.842	3.16
⅜ (3 ply)	0.00029	0.00102	0.00469	0.0163	0.0238	0.083	0.0750	0.261	0.183	0.637	0.380	1.32
⅜ (5 ply)	0.00030	0.00108	0.00478	0.0173	0.0242	0.087	0.0765	0.277	0.187	0.675	0.387	1.40
½ (5 ply)	0.00017	0.00055	0.00266	0.0088	0.0135	0.044	0.0427	0.141	0.104	0.343	0.216	0.711
⅝ (5 ply)	0.00011	0.00033	0.00171	0.0054	0.00866	0.027	0.0274	0.086	0.0668	0.209	0.138	0.433
¾ (5 ply)	0.00008	0.00023	0.00120	0.0037	0.00608	0.019	0.0192	0.059	0.0468	0.144	0.0971	0.298
¾ (7 ply)	0.00007	0.00022	0.00118	0.0035	0.00597	0.018	0.0189	0.056	0.0461	0.137	0.0957	0.283
1 (7 ply)	0.00004	0.00012	0.00067	0.0019	0.00338	0.010	0.0106	0.030	0.0260	0.074	0.0540	0.153
1⅛ (7 ply)	0.00003	0.00009	0.00050	0.0014	0.00256	0.007	0.00810	0.023	0.0197	0.056	0.0409	0.115

[a]Values for steel are for specimens faced on both sides with 0.024-in. steel; values for aluminum are for specimens faced on both sides with 0.016-in. aluminum.

zinc-coated steel and 0.016-in. aluminum, bonded to fir plywood. The plywood is laminated to the desired thickness and the metal facing is adhesive bonded to one or both sides.

For most standard laminates, the adhesive bond limits maximum continuous service temperature to about 170 F. Specially prepared laminates are available for continuous use as high as 350 F.

Fabrication

Although laminates are usually used as flat sheets, panels with metal facing only on one side can be formed to a certain degree. For example, a ¼-in. panel with steel on one side can be bent to a 9-in. radius by using rollers. Radii of 1½ to 2 in. can be obtained by routing the plywood or by using kerfs in the backing material.

Laminates can be sawed with hand, band, circular or jig saws, depending on the facing material and the type of cut desired. On panels faced on one side only, cuts should be made with the metal side up. Bank saws with 8-tooth, spring temper cutting blades are recommended for use at speeds of 11,000 fpm and feeds of 30 to 40 fpm.

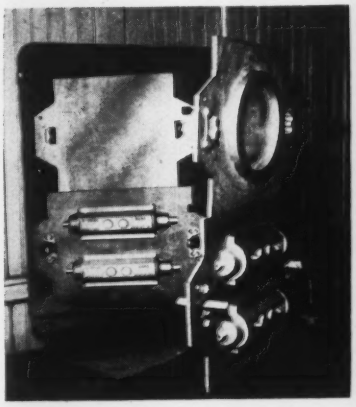
Panels can be drilled with ordinary metal cutting twist drills and bored with conventional boring tools.

Although any finish usable with the metal facing can be applied, where panels have metal facings on one side only a primer should be applied to the plywood side to seal pores and prevent distortion or warpage.

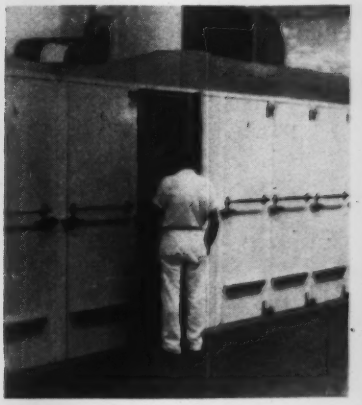
	84		96	
	Steel	Al.	Steel	Al.
	1.560	5.87	2.660	10.01
	0.704	2.44	1.202	4.17
	0.717	2.59	1.225	4.42
	0.400	1.32	0.682	2.24
	0.256	0.803	0.438	1.37
	0.180	0.553	0.307	0.943
	0.177	0.526	0.302	0.895
	0.100	0.284	0.170	0.484
	0.0757	0.214	0.129	0.364

Some current uses . . .

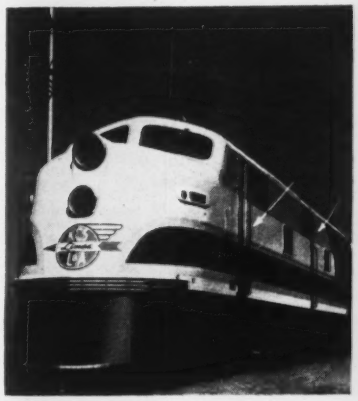
Lightweight rigidity, as well as smooth, mar resistant surfaces make metal-faced plywood an excellent material for . . .



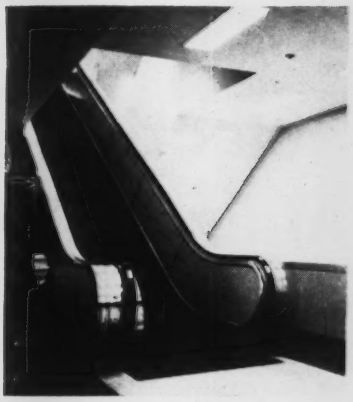
Foundry pattern boards



Bakery oven doors



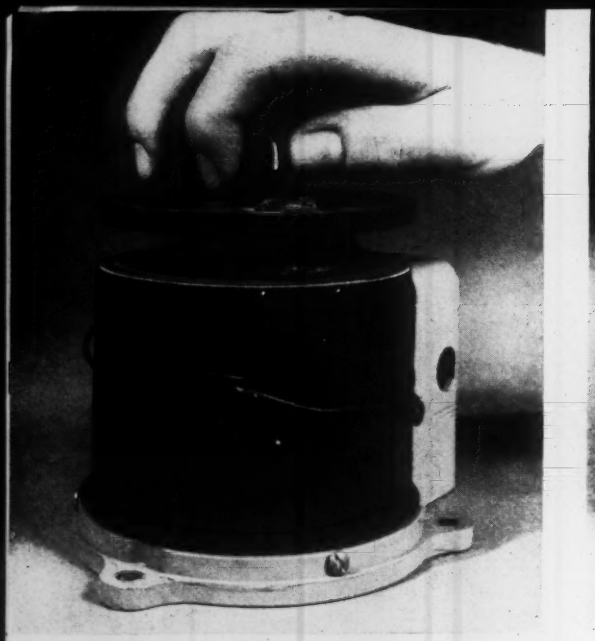
Locomotive sheathing



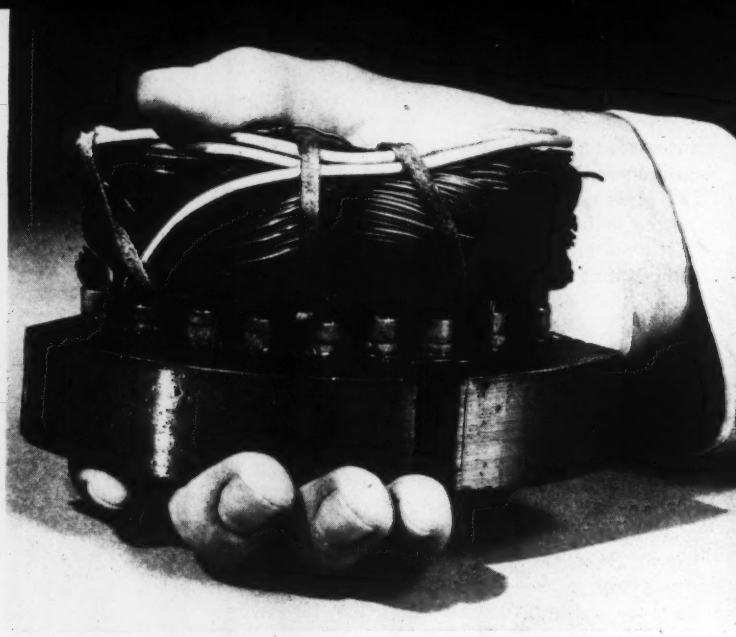
Escalator paneling

Railroad car interiors

Outdoor signs



Formvar *wire enamel is used on this auto-transformer because of its good all-around mechanical and electrical properties.*



Polyester-base *enamels provide excellent service on this stator for a fhp motor. Polyesters have been modified to improve heat resistance.*

Selecting a Magnet Wire Enamel

Here is an up-to-date summary on currently available enamels for insulating and protecting magnet wire:

- *What types are available?*
- *How do their properties differ?*
- *Where can they be used?*

by F. A. Sattler and F. F. Trunzo, *Research Laboratories, Westinghouse Electric Corp.*

■ Designers of electrical equipment and materials suppliers are continually seeking to find the one magic wire enamel formulation that will stand up under all operating conditions. However, such an enamel will probably never be developed. In recent years the demands of specialized applications have produced a wide range of new enamels designed for high temperature operation, solderability, high chemical resistance, and other special properties. Selection of the proper enamel is a difficult problem because of the number of materials that are available and the periodic changes made in formulations to improve properties.

The purpose of this article is to give the engineer an introduction to each major type of enameled wire—its advantages and shortcomings—and help him select the proper enamel for each application. In addition to the following description, a summary of enamel types, properties and costs is given in the large table on pp 106-107.

Oleoresinous

Of the various enamel materials investigated in the early 1900's, the first enamels that were commercially used were cellulose acetate and oleoresinous enamels. The oleoresinous enamel (sometimes called plain enamel) is still used in some applications today. Although it has poor resistance to severe winding abuse and attack by the solvents of many impregnating varnishes, it is inexpensive, has good water resistance, and stands up well over a wide range of service conditions.

Polyvinyl formal (Formvar)

A great many new enamels have been developed since the introduction of Formvar more than 20 years ago. Nevertheless, this enamel (a blend of polyvinyl formal and cresol formaldehyde resins) is still the most popular enamel in use today. Its success stems from 1) its good mechanical properties, such as flexibility, toughness and adhesion, which make for good windability, 2) its resistance to varnish solvents,

transformer oils and Freon-12 refrigerant, 3) its heat shock resistance (the ability to withstand high temperatures when elongated), and 4) the wide experience gained from using the material for a long period of time.

The problem of solvent crazing of elongated polyvinyl formal enameled wire has been solved by annealing the enameled wire before exposure to solvents. The high viscosity of the liquid enamel also is no longer a problem. However, the enamel still exhibits relatively poor resistance to thermal oxidation, although it has performed very well in 105 C (Class A) equipment for many years. The enamel softens badly in Freon-22 refrigerant and transformer askarels.

Nylon

In addition to its toughness and its resistance to heat shock and solvents, a nylon enamel has the added advantage of a slippery surface which enhances windability. Another advantage is that joints of nylon enameled wire can be soldered without stripping the nylon. Since nylon is thermoplastic it readily melts off in a hot solder pot. The enamel does not craze in the presence of solvents; however, it has poor resistance to water and thermal oxidation.

Nylon-jacketed Formvar

This composite enamel is especially useful in severe winding applications. The outer jacket of nylon provides a slippery surface and resistance to solvent crazing, and the polyvinyl formal layer provides excellent adhesion, toughness and good moisture resistance.

Polyester-amide

The main advantages of this enamel are its resistance to thermal oxidation, transformer oils and askarels. The enamel does not have the flexibility and heat shock resistance of a polyvinyl formal enamel, but it has been used successfully in many applications where severe winding abuse is not encountered.

Epoxy-modified polyester

This enamel has good resistance to thermal oxidation and excellent cut-through resistance. It also has good resistance to Freon-12 and transformer oil, and it has a thermal rating of 257 F (125 C) with a good organic varnish impregnant. However, the enamel does not have the heat shock resistance, flexibility and machine windability of a polyvinyl formal enamel.

Amine-catalyzed epoxy

Amine-catalyzed epoxy enamels have excellent resistance to moisture, alkalis, acids and heat shock. They also have excellent flexibility and good resistance to Freon-12 and Freon-22; however, their resistance to abrasion is only fair. When impregnated with a good organic varnish their thermal rating is about 239 F (115 C).

Silicone-modified polyester

Silicone-modified terephthalate polyester enamels have excellent resistance to thermal oxidative degradation, and indications are that they can be used continuously as high as 356 F (180 C) when impregnated with a silicone varnish. Modifications of these enamels have resulted in improved toughness and resistance to heat shock. However, these properties, as well as windability, are not on a par with those of nylon and polyvinyl formal enamels.

Terephthalate polyester

Terephthalate polyester enamels without silicone modifiers have better flexibility and toughness than silicone-modified polyester enamels, but they are not as thermally stable. Depending on the varnish impregnant used, they have sufficient thermal stability for use at 130 C (Class B) and 155 C (Class F) temperatures. Laboratory test data would indicate that the abrasion resistance and flexibility of terephthalate polyester enamels is comparable to that of polyvinyl formal enamels, but experience in severe winding operations at Westinghouse does not show this to be the case.

The resistance to heat shock and hot varnish attack of terephthalate polyester enamels is adequate for many applications, but is marginal on large diameter wire where sharp bends and high elongation are encountered. In sealed tube tests with water present at temperatures of 257 F (125 C) to 302 F (150 C), the polyester enamels degrade rapidly. However, some terephthalate polyesters have retained fair insulation properties after 72 hr in boiling water at atmospheric pressure. In this test they appear to withstand hydrolytic attack appreciably better than polyvinyl formal enamels.

Low, medium and high functionality resins — Terephthalate polyesters can be classed as low, medium or high functionality resins depending on the ratio of bifunctional to trifunctional (or tetrafunctional) polyol reacted with the dimethyl terephthalate.

High functionality, or highly crosslinked, polyesters have a very low weight loss with thermal aging. They also have long life in tests such as AIEE No. 57 when used in combination with a thermally stable varnish. High functionality polyesters have less initial flexibility than low functionality polyesters, and embrittle more rapidly during thermal aging due to increased curing during aging. However, the low and medium functionality polyesters have excellent retention of flexibility during aging.

Deposits of sublimed terephthalic acid appear on equipment containing polyester enamels when equipment is operated for long periods at 329 F (175 C) or above. To obtain full advantage of their thermal stability, polyester enamels should be used with compatible varnishes without vinyl sleeving. The degradation products produced from vinyl sleeving at high temperatures tend to degrade polyester enamels rapidly. Polyester enamels are not presently recommended in hermetic systems.

Modified terephthalate polyester —Thermally stable modifiers such as trifunctional isocyanate (Mobay Modur SH) have been blended with terephthalate enamels to improve their heat shock resistance, thermal stability and, to a limited ex-

***Dielectric strength** is probably the most important test in determining properties of wire enamels.*

***Continuity** of enameled wire is measured in this high speed testing machine.*

***Insulation resistance** and dielectric strength of enamels are measured at temperatures up to 932 F in this furnace.*

How Data Were Obtained

Temperature class

Temperature classification for each enameled wire was made using the AIEE No. 57 procedure. Standard NEMA dielectric twist samples, either unimpregnated or impregnated with a varnish, are aged at various elevated temperatures until breakdown occurs at 1000 v. The logarithm of average life at each temperature is plotted against the reciprocal of absolute temperature. This curve usually approximates a straight line and is extrapolated to an arbitrary life of 100,000 hr. Considerable controversy exists over the life limit used to determine operating temperature, some preferring a 30,000-hr life criterion.

The AIEE No. 57 procedure does not evaluate the effects of vibration or humidity cycling. These effects are included in Motorette (AIEE No. 510) and accelerated motor tests which are used to evaluate high temperature stability in complete insulation systems.

Scrape hardness

Scrape hardness was determined by pulling a 12-in. length of wire under a loaded knife with a 9-mil dia edge. The wire is scraped at intervals 90 deg apart, and hardness is measured by the weight required to scrape one-half of the enamel coating down to the bare wire on any one of the four sides.

Repeated abrasion

Repeated abrasion tests were made in a General Electric repeated scrape abrasion tester in which a constantly loaded knife (16-mil dia edge) abrades the enameled wire with reciprocating strokes ⅜ in. long. Repeated abrasion is measured as the average number of cycles required to abrade the enamel on three sides of the wire, 120 deg apart.

Flexibility, adhesion

In this test the enameled wire was elongated and then wrapped around a mandrel of the same diameter as the wire. An enamel is considered to have excellent flexibility and adhesion if it can be stretched to the breaking point of the wire (about 35%) and wrapped around its own diameter without cracking.

Automatic winding ability

Measurement of scrape hardness, abrasion resistance and flexibility are made mainly to estimate the performance of the enamel in winding operations. These tests are sometimes misleading, and the actual windability of enameled wire can only be verified by actual automatic winding tests. At Westinghouse these tests are performed by identically winding both a standard enameled wire and the enameled wire under test into a fractional motor stator. The enameled wire

tent, their water resistance. These formulations have shown promise on rectangular wire in providing good corner coverage, toughness and adhesion. However, heat shock failures occur at 302 F (150 C) with hairpin bends of rectangular wire, and better resistance to heat shock is needed for many applications. Preliminary thermal life tests (AIEE No. 57) show that the modified polyesters can be used for normal applications at 302 F when impregnated with a thermally stable organic varnish, and at 347 F (175C) when impregnated with a silicone varnish.

Polyurethane

Polyurethane enamels originated in Germany and are extensively used in that country for a wide range of electrical applications, including hermetically sealed equipment. The enamels consist of isocyanate blends with polyester resins of lower thermal stability than the terephthalate polyesters. Because of the rapid degradation of the urethane linkage at elevated temperatures, polyurethane coatings (like nylon) are solderable. Compared to nylon, the coatings have very good water resistance, lower dielectric loss at high frequencies, and

is then removed from the stator and the number of flaws developed during winding is measured by running the wire through a continuity tester.

Heat shock, hot varnish

The resistance of enameled wire to heat shock is determined by bending the wire around its own diameter into a coil having at least ten turns. The coil is placed in an oven at a predetermined temperature for 1 hr. Any cracking or flaking of the coating that occurs is considered to be a failure.

Resistance to hot varnish is determined by elongating the enameled wire to a predetermined percentage and dipping it into the impregnating varnish. The wire is then baked at the prescribed baking temperature of the varnish. Failure is indicated by cracking or loosening (called "tubing") of the enamel. In general, this is a more severe test than the heat shock test since the wire is in a stressed condition and must resist the combined effect of heat shock and attack by hot solvents. An enamel that shows marginal results in this test may subsequently exhibit cracking or crazing in actual use, particularly on large diameter wire with sharp bends.

Cut-through temperature

A high cut-through temperature is required to withstand occasional high overloads or the high temperatures required during varnish baking. Cut-through temperatures were determined by a special test which differs from that specified in JAN-W-583. In the test a 7-mil nickel wire, fixed at one end, is wrapped around a straight piece of enameled wire which is fixed at both ends. A standard weight is applied to the free end of the nickel wire and a voltage of 110 v is applied to the nickel wire. The temperature of the enameled wire is increased by means of a heating box until the enamel coating fails and is penetrated by the nickel wire. As soon as contact is made, failure is indicated by a signal in the 110-v circuit.

Chemical resistance

Moisture resistance was evaluated by determining the insulation resistance of enameled wire after immersion in water for various periods at room temperature and 212 F. The effect of moisture on enameled wire in a sealed glass tube at elevated temperatures was also studied.

Toluol resistance was measured by determining the change in scrape hardness of the enamel after immersion in toluol for 48 hr at room temperature. Solvent crazing was determined by stretching the wire slightly, soaking in toluol for 1 min, and examining for crazing.

Freon resistance was measured in a sealed tube using a 50-50 mixture of Freon and oil. Enameled wires previously stretched to various elongations were sealed in the Freon-oil mixture together with a strip of compressor flapper valve steel. The tube was heated at temperatures of 257 and 302 F for many weeks. During and after the test period the specimens were examined for enamel cracking and for deposits on the tube or the steel. In addition, the softening effect of Freon on enameled wire was determined in a special apparatus which measures the repeated abrasion resistance of the enameled wire while it is immersed in Freon.

Resistance to transformer oil and askarel was determined by aging standard NEMA twisted pairs of enameled wire in the test liquid together with strips of electrical iron and rag paper in loosely capped jars at 248 and 302 F. The time required to produce a breakdown at 1000 v was taken as a measure of the stability of the wire in the transformer liquid. There is some question regarding the validity of results obtained using this test since volatiles are allowed to escape more freely than in a sealed transformer. This is especially important in the case of the polyester enamels which may be attacked by the moisture released from the paper in a tightly sealed transformer system. An AIEE Working Group on Enameled Magnet Wire is currently designing a test which may more properly evaluate enameled wire in transformer systems.

better thermal stability.

Polyurethane enamels impregnated with a phenolic-alkyd varnish can be used continuously at 248 F (120 C). The enamels will not withstand severe winding abuse as well as polyvinyl formal enamels. In special windings where non-slip properties are needed to retain coil shape, polyurethane enamels are sometimes pigmented to provide a controlled coefficient of friction.

Nylon over polyurethane

This combination enamel is designed to improve the winding properties of a polyurethane enamel. The high abrasion resistance and low friction of the outer nylon layer help considerably in reducing winding abuse.

Self-bonding enamels

These enamels are specially designed so that heat or solvent treatment will bind the coil turn of the enameled wire. They are usually composite enamels consisting of a thermoplastic polyvinyl butyral topcoat over a polyvinyl formal or polyurethane base coat. They are rated as 105 C (Class A) enamels by most manufacturers.

Acrylic

Acrylonitrile terpolymer enamels (Lecton) have excellent flexibility and heat shock resistance, and good resistance to abrasion and Freon-22. Their performance in high speed winding machines is slightly inferior to that of polyvinyl formal enamels. When used in combination with a good impregnation varnish they have a thermal rating of about 230 F (110 C).

TFE

TFE (polytetrafluoroethylene) provides a very good outer layer in combination enamels because of its excellent thermal stability, slickness and good flexibility. Combination enamels such as TFE over ceramic and TFE over

Resin Type ↓	Temp Class[a], C	Heat Resistance		Mechanical Properties			
		Res to Heat Shock, Hot Varnish	Cut-Through Temp, C (F)	Scrape Hardness	Res to Repeated Abrasion	Flexibility, Adhesion	Automatic Winding Properties
Oleoresinous	90 (U), 105 (PA)	Poor	200 (392)	Fair	Poor	Fair	Poor
Polyvinylformal + Phenolic	80 (U), 105 (PA)	Exc	220 (428)	Exc	Good	Exc	Exc
Nylon	80 (U), 105 (PA)	Exc	264 (507)	Exc	Fair	Exc	Exc
Nylon over Formvar	80 (U), 105 (PA)	Exc	—	Exc	Fair	Exc	Exc
Polyester-Amide	130 (U), 125 (PA)	Fair	360+ (680+)	Exc	Fair	Fair	Fair
Epoxy-Modified Polyester	115 (U), 125 (PA)	Fair	360+ (680+)	Exc	Fair	Fair	Fair
Amine-Catalyzed Epoxy	110 (U), 115 (PA)	Exc	280 (536)	Exc	Fair	Exc	Fair
Silicone-Mcdified Polyester	180 (U), 140 (PA), 185 (S)	Fair	350 (662)	Fair	Fair	Good	Fair[d]
Terephthalate Polyester (medium functionality)	155 (U), 140 (PA), 145 (IP), 160 (S)	Fair	310 (590)	Fair	Good	Exc	Fair
Isocyanate-Modified Terephthalate Polyester	170 (U), 150 (PA), 160 (IP), 175 (S)	Good	345 (653)	Good	Good	Exc	—
Terephthalate Polyester (high functionality)	140 (PA), 160 (IP), 185 (S)	Fair	350 (662)	Fair	Exc	Fair	Good
Polyurethane	120 (PA)	Good	285 (545)	Good	Good	Good	Good
Nylon over Polyurethane	—	Good	265 (509)	Exc	Exc	Good	—
Self-Bonding Enamel over Formvar	—	Exc	215 (419)	Good	Exc	Exc	—
Acrylonitrile Copolymer	90 (U), 110 (PA)	Exc	283 (541)	Exc	Good	Exc	Good[d]
Polytetrafluorcethylene (TFE)	200	Exc	156 (311)	Poor	Poor	Fair	Poor
TFE Combination	250	Exc	350+ (662+)	Poor	Poor	Fair	Poor
Anodized Aluminum	500	Exc	>500 (>932)	Fair	Poor	Poor	Poor
Ceramic	400-600	Exc	>500 (>932)	Fair	Poor	Poor	—
Organic + Ceramic	500	Fair	>500 (>932)	Poor	Poor	Poor	—

[a]Temperature class of enameled wire was determined using the following varnish impregnants: PA, phenolic-alkyd varnish; IP, isophthalate polyester varnish; S, silicone varnish; U, unvarnished.

[b]These were preliminary high temperature tests (at 248 and 302 F) in loosely capped jars; hence, the effect of hydrolytic attack was not evaluated.

silicone (pigmented and unpigmented) can be used up to 392 F (200 C) on copper wire. Above 392 F the copper wire begins to oxidize and the oxide flakes off along with the insulation in a relatively short time. Nickel-plated copper (5 to 10% nickel) is generally used to realize the high temperature potential of TFE enamels. The thermoplastic flow of TFE (used alone) at high pressure points can sometimes cause cut-through problems.

Inorganic coatings

Anodized aluminum wire (aluminum oxide insulation) can withstand moderate bonding without flaking. However, the thin films required for good adhesion result in relatively low dielectric strength

Chemical Resistance								Application
Moisture	Toluol		Freon		Transformer Fluids[b]		Relative Cost[c]	
	Craze	Soften	12	22	Oil	Askarel		
Exc	No	Yes	—	—	Fair	Poor	1.00	Magnet coils with low winding abuse. Low cost, excellent moisture resistance
Good	Yes	No	Good	Fair	Fair	Poor	1.05	High speed automatic motor windings, Freon hermetic motors, oil-filled transformers, magnet coils for general use, rectangular wire applications
Poor	No	No	Fair	Fair	Fair	Poor	1.05	Solderable enameled wire, automatic winding applications
Fair	No	No	—	—	—	—	1.05	Severe high speed winding applications
Fair	No	No	Good	Good	Exc	Good	1.05	Oil-filled transformers, specialty transformers, motors, control coils, hermetic refrigeration motors. Good resistance to encapsulating polyesters and epoxies
Good	Yes	No	Exc	Fair	Exc	—	1.05	Oil-filled transformers, motors, and transformers and coils with high overloads. Good cut-through resistance
Exc	Yes	No	Exc	Good	Exc	Poor	1.05	Oil-filled transformers, Freon hermetic motors, rectangular wire. General use for moisture and chemical resistance
Fair	No	No	Fair	Fair	Exc	Exc	1.27	180 C (Class H) applications with silicone impregnant. Motors, transformers, control coils (unsealed systems
Fair	Yes	No	Fair	Fair	Exc	Good	1.05	130 C (Class B) motors, transformers and control coils (unsealed systems). 155 C (Class F) coils with high temperature varnishes
Fair	Yes	No	Fair	Fair	—	—	1.05	155 C (Class F) motors, transformers, control coils with polyester or silicone varnishes. Unsealed systems
Fair	No	No	Fair	Fair	Exc	Exc	1.05	180 C (Class H) applications with silicone varnish. 155 C (Class F) applications with polyester varnish. Unsealed systems
Exc	Yes	No	Fair	Fair	Good	Fair	1.05	Solderable enameled wire for electronic uses. General use where high overloads are not encountered. Low dissipation factor, excellent moisture resistance
—	No	No	—	—	—	—	1.05	Similar to polyurethane, but nylon overcoat is reported to improve windability and solvent crazing resistance
Fair	Yes	No	—	—	—	—	1.08	Self-bonding coils. No varnish required
Good	Yes	No	Good	Good	Good	Poor	1.07	Freon hermetic units, particularly Freon 22. General uses
Fair	No	No	Good	Good	Good	Good	6.3	Applications up to 200 C (on special metals or protected copper) where high pressure points do not exist. Special care in winding required
Fair	No	No	—	—	Good	Good	7	250 C applications (special conductors). Underlayers eliminate cut-through problems. Careful winding required
Porous	No	No	—	—	—	—	—	Ultra-high-temperature aircraft equipment and missiles. Must be canned for moisture resistance. Care in winding required
Porous	No	No	—	—	—	—	50	
Porous	No	No	—	—	—	—	20	

[c]All costs are relative to oleoresinous enameled wire which was assumed to have a value of 1.00. Thus, nylon enameled wire with a value of 1.05 costs approximately 1.05 times as much as oleoresinous enameled wide. Costs are based on No. 17 AWG heavy build enameled wire.

[d]Latest formulation not evaluated.

(200 to 400 v wire-to-wire in air). In general, the previous conclusions also apply to ceramic-coated magnet wire.

Ceramic-filled organic resins have been developed that utilize the flexibility of the organic binder to improve flexibility during winding. After winding, the organic resin is burned out and the ceramic is sintered. These materials also show low wire-to-wire voltage breakdown (400 to 600 v).

The performance of inorganic coatings in ultra-high temperature motors, transformers and coils is still being evaluated. Because of their porosity, the coatings must usually be specially processed to obtain good moisture resistance.

Cold Finished Steel Cuts Cost of Precision Parts

The reasons: close tolerances, good machinability and smooth finish.

by L. U. Davis, *Supervisor, Product Technical Services, Jones & Laughlin Steel Corp.*

Faster production *of shafts for portable electric tools was achieved by Black & Decker Mfg. Co. using cold finished steel bar.*

■ All cold finished steel products begin as hot rolled steel. In comparison with hot rolled steel, cold finished products are free from scale, closer to nominal size, and straighter. When produced by cold rolling or cold drawing, the bars have better mechanical properties than hot rolled bars.

Cold finishing is performed by any one of five operations:

1. Cold drawing.
2. Cold rolling.
3. Turning and polishing.
4. Cold drawing, grinding and polishing.
5. Turning, grinding and polishing.

The hot rolled mechanical properties are not changed in the turning, grinding and polishing operations.

Shapes and sizes

Cold finished steel products are produced in four standard shapes: rounds, squares, hexagons and flats. Sizes available in these shapes are:

Rounds—up to 18 in., incl.
Squares—up to 6 in., incl.
Hexagons—up to 4½ in., incl.
Flats—⅛ in. and over in thickness and up to 14⅝ in. in width.

Special shapes, tailor-made to suit various applications, are also available.

TABLE 1—STANDARD TOLERANCES

Size, in.[a]	Finish	Tolerance, in.	
		Over	Under
½.....	Hot Rolled.....	0.007	0.007
	Cold Finished[b]..	0.000	0.002
1.....	Hot Rolled.....	0.009	0.009
	Cold Finished[b]..	0.000	0.002
2.....	Hot Rolled.....	0.015	0.015
	Cold Finished[b]..	0.000	0.003

[a]Round. [b]Max carbon 0.28%.

Dimensional accuracy

A comparison of the standard tolerances for several sizes of hot rolled and cold finished bars is given in Table 1. This table is representative only. A complete table of cold finished bar tolerances would indicate that a wider range is required if the carbon content is over 0.28%, or if the bar is to receive a thermal treatment. For instance, the tolerance varies as follows for bars 1½ in. in dia and under:

Carbon 0.28% max..exact to –0.002
Carbon 0.28 to 0.55% max.....exact to –0.003
All grades stress relieved.....exact to –0.004
Carbon over 0.55% or all grades heat treated before cold finishing .....exact to –0.005

Closer size limits than these can be obtained on cold finished bars if required, but a special setup is necessary and the price of material correspondingly higher.

Mechanical properties

When the bar diameter is reduced by cold working, as is the case in cold rolling or cold drawing, the metal becomes harder and less ductile, and the tensile and yield strengths are raised.

Representative mechanical properties of hot rolled and cold drawn material are given in Table 2. The increase in yield strength occurring in all of the steels is a very important property of cold drawn material. For example, a comparison of the mechanical properties of cold drawn C 1020 and hot rolled C 1035 shows that they have the same tensile properties but C 1020 has a higher yield strength.

Control of mechanical properties — Frequently cold finished bars are ordered to a specification having mechanical property requirements beyond the range of normal practice. As a first step, the chemical limits permissible for the part are explored and the grade that comes closest to meeting the required tensile and yield strengths is selected. After this selection, it is possible to alter the

mechanical properties by various methods.

One of these methods is special drafting. Generally, in cold drawing, the draft (reduction in diameter from hot rolled to cold finished size) ranges from 1/32 in. to 1/16 in. Heavier drafts up to 1/8 in. can be used to produce higher than normal mechanical properties. These property improvements can be further enhanced by strain-aging at about 550 to 600 F, as shown in Table 3.

Strain-aging of steels such as C 1030, C 1137, C 1141 and C 1144 normally results in an increase of approximately 5000 psi in yield and tensile strengths Temperatures over 600 F cause the yield strength to decrease; the tensile strength starts to decrease at a stress relieving temperature of about 850 F. If higher temperatures are used, the bar will eventually show mechanical properties approximating those of a hot rolled material; this occurs at about 1200 F. Thus, mechanical properties can be raised or lowered by selecting the proper aging or stress relieving temperature.

Electric induction heating is another method of improving properties. Bars are heated by induction coils and rapidly cooled by water spray. By selecting suitable tempering temperatures the hardness can be dropped to the desired range. For example, take C 1141 grade with modified carbon content of 0.40-0.48%. Normally Rockwell C25 is easily reached by cold drawing and strain tempering. With induction heating, a hardness of Rockwell C35 can easily be attained. Higher hardness can be met with this process, but bar straightness becomes a problem.

Machinability

Cold finishing operations improve machinability. On turned bars, the improvement comes from the removal of abrasive scale. In cold drawn material, machinability improvement results from the changes in mechanical properties.

Of course the machinability of a steel is also dependent upon its chemical analysis; carbon, manganese, phosphorus, sulfur and silicon all play a part in determining the machining performance. Sulfur is the major element in controlling machinability. Further improvement can be obtained by the addition of 0.15 to 0.35% lead.

The austenitic grain size and the actual as-rolled grain condition influence machinability. Coarse grained (austenitic grain size) stock machines better than fine grained. Annealing before cold drawing improves machinability of grades such as C 1045, C 1050, and C 1141. The annealing cycles are usually set up to produce a lamellar pearlite structure. Cold drawing in itself does not change

Some Selection Pointers

For free machining

1. High sulfur leaded grades are best.
2. Strain aging at 500-600 F generally improves machinability of cold drawn bars.
3. Cold drawn bars are preferable to turned bars, particularly in the lower carbon grades.
4. Killed or semi-killed steels are preferable to rimmed steels.
5. Coarse austenitic grain is preferable to fine grain.
6. If high sulfur or lead are not permissible, annealing is beneficial on the higher carbon grades such as C 1045 and C 1050.

For hardening by heat treatment

1. Steels containing less than 0.30% carbon should be case carburized and quenched if high surface hardness is required.
2. High manganese grades (C 1117, C 1118 can be easily carburized; after quenching they have higher core hardnesses than low manganese grades (C 1016, C 1018).
3. Steels containing over 0.30% carbon can generally be hardened by quenching.
4. Normalized material will distort less on quenching than material that has not been normalized.
5. In induction hardening, microstructure is an important factor. Coarse lamellar pearlite will not harden as well as fine lamellar pearlite. Decarburization causes low surface hardness.
6. Fine-austenitic-grain steels are shallower hardening than coarse grained steels.

For cold forging or cold heading

1. Open hearth steels are superior to bessemer grades.
2. Low carbon steels can be upset moderately without stress relieving or annealing.
3. Carbon steels containing from 0.20 to 0.30% carbon may require thermal treatment to relieve cold drawing strains; stress relief at 800 to 1200 F may suffice.
4. With carbon contents above 0.30%, thermal treatment varying from high temperature stress relieving to spheroidizing may be required.
5. Open hearth steels are recommended for roll threading.

For welding

1. Grades low in sulfur are more readily welded than the high sulfur grades.
2. Steels having carbon contents lower than 0.30% are more easily welded than higher carbon steels.

Relative Cost of Bars

Hot rolled	**100**
Cold drawn	130
Cold rolled	130
Turned and polished	150
Cold drawn, ground and polished	200
Turned, ground and polished	200

the grain enough to show up in normal microscopic examination.

The free-machining grades are the C 1200, C 1100 and B 1100 series. A relative comparison of the machinability of steel has been arrived at by using B 1112 as 100% when turning at 160 sfm; on this basis, B 1113 rates 135% and leaded B 1113 rates 170%.

Thermal treatments can be used to improve the machinability of some grades, and to improve surface hardness on heat treated bars. Higher carbon steels can be fully annealed before or after cold drawing; by proper control, grain structures can be obtained that will make the steel more machinable or more able to withstand severe cold upsetting and cold forging. Carbon can also be restored to the bar surface and make it possible to obtain maximum surface hardness on heat treating.

Applications

Cold finished bars—A primary use of cold finished bars is the manufacture of precision parts on automatic screw machines. The dimensional accuracy of the bars serves a dual purpose. It allows the feed fingers and collets of the automatic screw machine to work efficiently and freely, and it eliminates the necessity of machining the major diameter when this diameter is the same size as the bar.

The straightness of cold finished bars is a major factor in eliminating vibration in the material while it is running at relative high speeds in automatic machines. Tool life and spindle bearing life can be severely impaired if straight bars are not employed in these operations.

Some of the products made on automatic screw machines from cold finished bars are spark plug shells, piston pins, bolts, bushings, distributor cams, gears, grease fittings, locknuts, motor shafts, spline shafts and taper pins.

Cold finished bars are ideally suited for shafting because shafting must be close to size, true to roundness, and straight. Before the electric motor came into use, line shafts accounted for a good share of cold finished bar production. Individually powered equipment has decreased the need for line shafting, but a large share of the cold finished production goes into numerous shafts in automobiles, farm machinery, electric motors, machine tool equipment and appliances. The close size and straightness of cold finished bars is directly responsible for this usage.

The term shafting does not apply to any particular grade of steel. Grades used are C 1010, C 1019, C 1045, B 1112, C 1212, C 1117, C 1118, C 1137, C 1141 and C 1144. The higher sulfur steels are ordered if machinability is of importance to the user. Hardness and tensile strength can be controlled by carbon and manganese content or by cold finishing practice.

Cold rolled flats — Cold rolled flats are used for fabricating jig and fixture components, for stamping die parts such as stopper plates and stock guides, and for general use in machine tools. Freedom from scale allows the user to weld the flats without surface preparation. Uniformity of size is also important. In many instances the fabricated part will require no machining excepting squaring the ends to eliminate irregularities resulting from cutting the piece from the mill length.

Turned and polished bars—Such bars are used primarily for large diameter shafting. If the shaft is expected to operate at extremely high speeds, e.g., in an air conditioner fan, it must be close to size, have special straightness and a smooth surface, be free from pits, and be in a condition that prevents warping. Turned and polished, and turned, ground and polished stock are ideally suited for this type of job. They can be produced with close size, and the removal of surface metal and the smoother finish that are obtained will reduce the hazard of fatigue failures. Stress relieving of cold drawn material can also be used to combat distortion.

Drawn, ground and polished bars—These bars are fabricated into parts requiring extreme dimensional accuracy and high finish. Some typical applications are typewriter and business machine parts, hydraulic cylinder rods, small electrical motor shafts, fuse parts for shells, and sucker rods for well pumps.

Turned, ground and polished bars—These bars find their place in the manufacture of large pump shafts, and component parts of printing presses and textile machinery.

TABLE 2—MECHANICAL PROPERTIES

Grade	Finish	Size, in.[a]	Yld Str, 1000 psi	Ten Str, 1000 psi	Elong (2 in.), %	Red. of Area, %	Brinell Hardness
C 1020	Hot Rolled	1 1/16[b]	35.2	59.1	30	55	118
	Cold Drawn	1	65.1	75.8	20	52	156
C 1035	Hot Rolled	1 1/16[b]	45.2	75.1	25	45	149
	Cold Drawn	1	75.2	85.2	15	41	197
C 1045	Hot Rolled	1 1/16[b]	50.1	89.1	20	40	179
	Cold Drawn	1	90.2	100	10	35	212

[a]Round. [b]For cold drawing to 1-in. rounds, the hot rolled size is 1 1/16 in.

TABLE 3—PROPERTIES OF COLD DRAWN ROUNDS
(C 1141, 1¼ In. Dia)

Finish	Yld Str, 1000 psi	Ten Str, 1000 psi	Elong, %	Red. of Area, %	Brinell Hardness
Regular Cold Drawn	85	95	10	30	187
Special Cold Drawn[a]	95	105	10	35	235

[a]Heavy drafting followed by strain aging at 550-600 F.

Next Month!

Materials
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FEATURES

- **SOLID URETHANE ELASTOMERS**
  Strange materials: half plastic, half rubber—seven well-engineered commercial uses for **elastomers** in detail.
- **TITANIUM MILL PRODUCTS**
  File Fact for October.
  Designation and availability data.
- **DESIGN REPORT**
  "Die Castings"—your 16-page October MANUAL —alloys used, properties, comparisons with other forms, design solutions.
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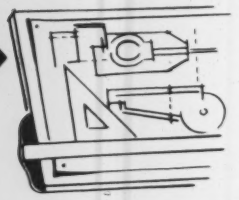

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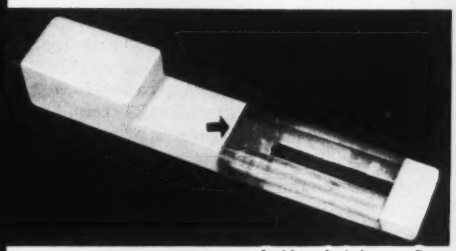
Rubber & Asbestos Corp.

Metal-to-plastic



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Plastic-to-plastic

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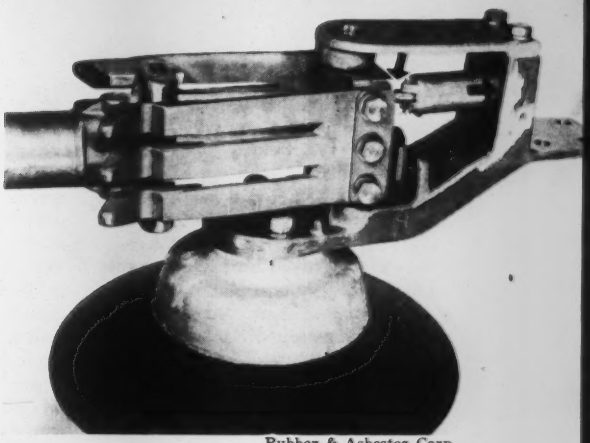

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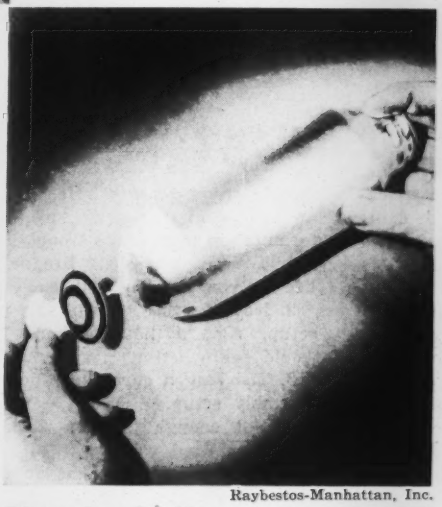

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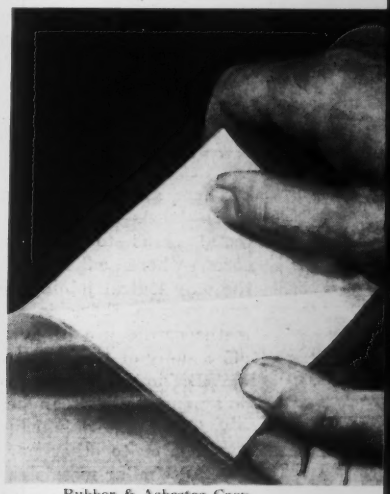

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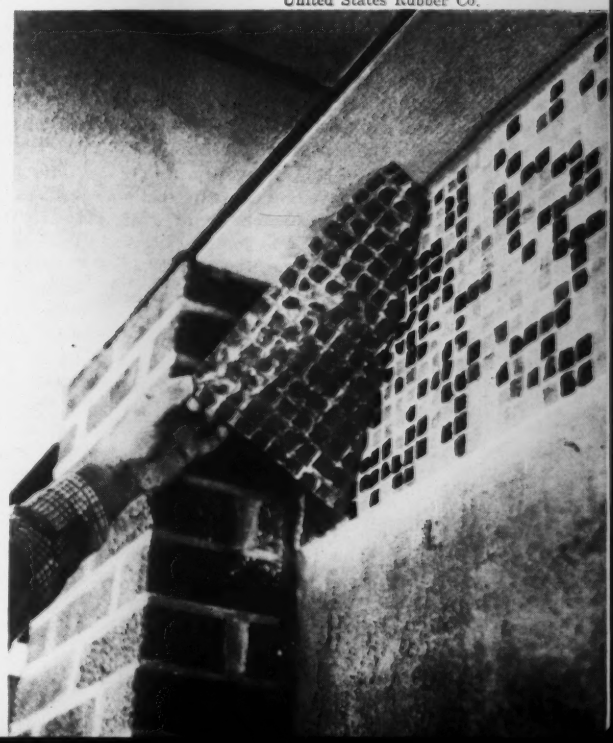


Adhesive Bonding

by Jack C. Merriam, *Associate Editor, Materials in Design Engineering*

- *Why adhesive bond*
- *How adhesives are classified*
- *Requirements for bonding*
- *Structural adhesives*
- *The seven steps in bonding*
- *Joint design*
- *Where bonding is used*
- *Definitions of bonding terms*

■ Can adhesive bonding solve your joining problem? Can it be used to advantage to replace the joining method—welding, brazing, soldering, mechanical fastening—you are now using?

It may be that no one but a reliable, experienced formulator can answer these questions. Although you may read here, or elsewhere, of an application that matches or parallels your own case, the odds are great that you will find the supplier recommending a different formulation, a different adhesive form, possibly a different chemical group. Many suppliers will refuse to sell you a formulation you ask for until they can determine that it is the best for your purpose. Most have standard questionnaires that you or their representatives must answer. It is not enough to know the materials being joined; the product design, the end-service conditions to be met, your production line setup—all play their part in the final determination.

Why, then, this manual? Because, most of all, recognition of what adhesive bonding is doing today, and can do tomorrow, is necessary before you can intelligently consider it for your problems. The developments that have taken place in the plastics resins field—and the progress in adhesives stimulated by aircraft and missiles programs—are making their mark on the industrial adhesives market. In 1959 it is expected that 450 million pounds of synthetic adhesives alone will be used, and used in more diverse applications than ever before. This is a 15% increase over 1958 usage.

Secondly, you must be convinced of the need for the many formulations that exist—and of the necessity for the constant development of new formulations. This means understanding the way in which the many factors summarized above play their part in the final choice of an adhesive.

Last of all, providing we do not attempt to break down our discussion to specific formulations—but confine ourselves to types and forms—the adhesives picture is not such a complicated one after all.

Why adhesive bonding?

There are many obvious applications—labels to bottles and cans, metal skins to plastics sandwich cores—where adhesive bonding is the only logical joining method. But even where there is a choice of methods, the use of adhesives may offer many of these ten advantages:

1. Dissimilar materials, e.g., metals and nonmetallics, can be joined.
2. Thin materials can be joined together or to other parts.
3. Dissimilar metals can be joined without metallic corrosion.
4. Joined metals may be electrically insulated by the adhesive.
5. Joined parts may be sealed against liquids by the adhesive.
6. Joined parts can provide a smoothly contoured surface.
7. Loads are uniformly distributed by the extensive bonding surface.
8. Vibration resistance and damping are supplied by the adhesive.
9. Design can often be simplified, saving weight and/or money.
10. Costs may be reduced in many of these areas: personnel; speed of assembly; cost of the joining material itself; grinding, filing and other "after" operations; and design.

What are its limitations?

Any particular adhesive formulation, or even a particular chemical group or form, will have definite limitations. It is for this reason that adhesives are formulated to meet specific requirements. Here, first, are some of the ways a wrong formulation may cause trouble:

1. Too short a shelf life or pot life for your intermittent usage.
2. Not the best form for your setup, e.g., a liquid where tape would serve better.
3. Too long a cure time for your assembly setup.
4. Not enough flow or thickness to fill required voids.
5. Requirements of heat or pressure beyond your equipment.
6. Adhesive solvent reacts chemically to deteriorate the adherend (or adherend coating).
7. Adherend reacts chemically to weaken the adhesive.
8. Wrong kind of strength, e.g., high peel strength and low shear strength when reverse is needed.
9. Poor resistance to heat, humidity or other environment to which the bond will be exposed.
10. Bond affected by some chemical to which it will be exposed.
11. Too high quality and therefore too high cost.

These problems do not rule out adhesive bonding. They can generally be solved by having your supplier find the right adhesive for you, or by having him formulate one to meet your specific requirement.

What of the problems that do rule out adhesive bonding altogether? It may well be that a redesign can still prove the feasibility of using adhesives. Of course, there are some materials, such as polyethylene or fluorocarbon plastics, which are difficult to bond with adhesives. They can be bonded, however. It becomes a matter of meeting service conditions or justifying the cost of special grades, pretreatments or adhesives.

The chances are, then, that the serious limitations you may encounter will be one of these two end-service conditions:

1. *High temperature.* Organic adhesives cannot successfuly be used at temperatures much above 450 F, and above about 350 F they must be carefully protected from oxidation. Ceramic adhesives, still in the research and development stage, may prove feasible at temperatures of 800 F and higher.

2. *High strength.* The present limits are about 8,000 to 10,000 psi for tensile strength and 6000 to 8000 psi for block shear strength.

There is also the possibility, though unlikely, that your requirements for materials, production setup, various strengths and environment resistance, may each demand the best that is possible from all adhesives. No one adhesive can satisfy such a demand. In any formulation certain necessary properties are obtained only at some expense to other properties. But there are compromises and these prove satisfactory in the majority of cases. It cannot be stressed too strongly that many designers are "overdesigning" or "overspecifying" the properties required of adhesive-bonded joints. In this field such practice is not "safety"; it is simply demanding compromises that are unnecessary.

COVER: Upper left—high fidelity speaker system; upper right—high voltage airbrake switch; center left—stroboscope tube component; center middle—vacuum thermos bottle; center right—electrical slot insulation; lower right—exterior wall tiles.

How adhesives are classified

There is more than one way to classify adhesives. Actually, each formulation is unique in itself, definable by the materials joined, the form in which the adhesive is used, the method of applying and curing the adhesive, the strength properties of the bond and the end-service conditions it is expected to resist. Adhesives can be most usefully classified by each of these qualities.

Another way of classifying, not mentioned, is to refer to the chemical composition of the adhesive. This system is of limited value to the user, yet is the most common one. Only thus can broad generalizations about forms, uses and end-service properties be drawn to give you an appreciation of the capabilities of adhesive bonding. Such a classification method will be followed here, too, but first let us see what can be said about those other factors mentioned previously. They are the ones the formulator will describe when he discusses his recommended adhesive with you.

Materials to be joined

You may have seen charts listing materials—similar and dissimilar—which are to be joined, together with recommended adhesives, defined by chemical group, for joining them. No such charts appear in this manual. They are not only too broad to be of value; they can be misleading. There is generally a choice of many chemical adhesive groups and the decision is based on other factors—perhaps as simple a factor as cost, perhaps as complex as end-service conditions.

Nevertheless, it is true that some properties of the materials may limit the choice of adhesives. These are special cases and must be treated independently by the formulator. Some of these properties are:

1. Modulus of elasticity.
2. Thermal coefficient of expansion.
3. Porosity.
4. Strength.
5. Susceptibility to attack by solvents which may be used in the adhesives.
6. Ability of the plasticizer in some materials to soften certain adhesives.
7. Failure to respond to the mechanics of adhesion with the particular adhesive.

Generalizations about adherends, to the extent that they are feasible, will be made later when discussing the chemical classification of adhesives.

Form of the adhesive

It can be seen from Table 1 that choice of an adhesive form is largely based on your production setup. This is not, however, the sole factor. The

TABLE 1—ADHESIVE FORMS

Form ↓	Remarks	Advantages
Liquid	Most common form. Practically every formulation available. Principally solvent dispersions, some water emulsions and latexes	Easy to apply. Viscosity often under control of user. Major form for hand application.
Paste	Wide range of consistencies. Limited formulations. Structural adhesive pastes are principally modified epoxies	Lends itself to high production setups because of less waiting time. High shear and creep strengths
Powder	Require mixing or heating to activate curing	Longer shelf life. Mixed in quantities needed
Mastic	Applied with trowel	Void-filling, nonflowing
Film, Tape	Supported and unsupported. Usually limited to surfaces of flat or smooth nature. Wide range of curing ease	Quick and easy application. No waste or runover; uniform thickness
Other	Rods, precoated copper for printed circuits, etc.	Ease of application and cure for particular use

TABLE 2—ADHESIVES CLASSED BY ACTIVATION AND CURE REQUIREMENTS

Requirement ↓	Types Available	Forms Used	Remarks
Heat	Rm temp to 450 F types available; 250 to 350 F types most common for structural adh	Formulated in all forms; liquid most common	Applying heat will usually increase bond strength of any adh, even rm temp types
Pressure	Contact to 500-psi types available; 25 to 200-psi types most common for structural adh	Formulated in all forms; liquid or powder most common	Pressure types usually have greater strength (not true of modified epoxies)
Time	Types requiring a few seconds to a week available; ½ to 24-hr types most common for structural adh	Formulated in all forms	Time required varies with pressure and temp applied and immediate strength
Catalyst	Extremely varied in terms of chemical catalyst required; may also contain thinners, etc.	Two components paste (or liquid) + liquid	Sometimes catalyst types may require elevated temp (<212 F) and/or pressure instead of, or in addition to, a chemical agent
Vulcanizing	Varied types requiring addition of a chemical agent (usually sulfur); may also contain a catalyst	Two liquid components	Premixed types requiring 250 to 350 F for vulcanization are available
Reactivation	Types requiring heat or solvent or second coating of adh	Dry film or previously applied liquid	Heat type is best for nonporous surfaces and/or max strength

nature of your design, availability, and cost considerations also play a part.

Recently, film-type adhesives have been finding increased usage in the structural field, despite the fact that the cost of the adhesive itself is higher. They are available, supported or unsupported, as pressure sensitive, solvent-reactivated or heat-reactivated types. For structural uses they usually require heat and/or pressure cures.

When cured under pressure, film adhesives soften to a semi-fluid state and thoroughly wet the surfaces they contact. Continued heating of most films results in a cure that produces high peel and bend strengths as well as good low temperature shear strengths.

In general, film adhesives provide: uniform thickness throughout the joint, controlled confinement to the immediate area (the tape is cut to fit the bonding surface), clean bonding operations, and simple application procedures. They are also available with a different chemical type of adhesive on each side.

Along with form the flowability of the adhesive might be considered:

1. *Flow* types provide an even glue line and smooth surface in addition to the obvious advantage of filling crevices and complex joints. They are applied in the form of liquids and either thin or heated pastes and may be solvent dispersions or water emulsions.

2. *Nonflow* adhesives do not sag, can fill voids and gaps, require no "clean-up," and can be applied vertically or overhead. They are applied in the form of a heavy paste or trowelable mastic. Important among the structural types is a 100% solids epoxy resin adhesive termed "void-filling."

Flowability is, of course, a relative term and is affected by such factors as temperature, pressure, joint design, time left standing, and the mixing of catalysts or solvents.

Cure requirements

This classification is related to the chemical group of the adhesive but is discussed separately for clarity. Two or more cure requirements listed in Table 2 may have to be satisfied for any one adhesive. The temperatures, pressures and curing times stated in the table as being "most common" are for adhesive "alloys."

The area of cure requirements is one that is certain to show advances in the near future. Although some chemical types of adhesives require heat and pressure to develop maximum bond strength, this limitation does not apply to modified epoxies. It is still true, however, that bonds to withstand higher temperatures must be heat cured. This limitation is one that formulators have been striving for years to overcome.

Omitted from Table 2 are those adhesives which may loosely be said to require no cure. Among these are: "hot-melt" adhesives which are heated before applying and set upon cooling, "contact-bond" adhesives which bond to themselves for a specified period of time after the coating has dried, and "pressure sensitive" adhesives which bond to most surfaces for an almost indefinite period of time after drying.

One unique adhesive, in a class by itself, must be mentioned in connection with cure requirements. Designated Eastman 910, it is a product of Eastman Chemical Products, Inc. The main component is known chemically as methyl 2-cyano acrylate. When the adhesive is spread thinly, room temperature curing takes place almost immediately under contact or light pressure, without the addition of a catalyst or the evaporation of solvents. The adhesive is extremely versatile with respect to materials bonded and develops bonds of high strength. It is, however, extremely expensive and not recommended for hot, humid environments. Further studies are being made concerning end-service conditions.

What Is An Adhesive Formulation?

There is more to a formulation than the one or two basic resins (which are the active adhesive materials) and the vehicle (which is usually water or a volatile solvent). Although the types and proportions of these major components may be the decisive factors in determining the nature of the adhesive, other agents are usually necessary:

Catalysts—A great variety of chemical agents are used to initiate and accelerate the chemical process of curing the applied adhesives. They may be added separately at the time of application or activated by heat and/or pressure.

Extenders—Low cost substances such as starch, gelatin, or lower grade resins used to reduce the amount of primary binder and therefore the cost.

Fillers—Non-adhesive materials added to produce changes in the working characteristics, bonding requirements or such specialized end-service requirements as electrical properties or color. Walnut shell flour, graphite, clay, asbestos, metal powders and glass fibers are typical.

Inhibitors—Chemical agents which slow down the curing action, usually to prolong storage or working life.

Plasticizers—Usually organic liquids added primarily to give softness, ductility and flexibility. They may reduce adherence to non-absorbent surfaces. Also termed "softeners."

Pigments—Used to add color, usually matching the adherends.

Stabilizers—Chemicals such as benzoic or lactic acid added to improve resistance to heat, light or decomposition.

Wetting agents—Anionic or cationic agents added to insure good wetting of the adherend surface, particularly for adhesives to be sprayed.

Thus a formulation may vary from simple to complex, and many formulations are possible using the same binder resins, each with different properties. The following is a typical formulation for a thermosetting-thermoplastic structural adhesive (percentage by weight):

Polyvinyl formal resin	12
Phenolic resin	6
Ethylene dichloride	41
Methylethyl ketone	20.5
Ethanol (95%)	20.5

The five chemical groups

For convenience, commonly used adhesives may be classified as one of the following five types:

1. Natural (Table 3)

This term is used to include vegetable and animal-base adhesives and natural gums. The various types will not be described separately, as their usage is mostly limited to paper, cardboard, foil and light wood. They are cheap and easy to apply and have a long shelf life. They develop tack quickly, but possess low strength properties. Most are water soluble and use water as a solvent. They are supplied as liquids or as dry powders to be mixed with water. An exception is the casein-latex type which consists of combinations of casein with either natural or synthetic rubber latex. This type is used to bond metal to wood for panel construction and to join laminated plastics and linoleum to wood and metal, but is being replaced by the organic resin adhesives.

2. Thermoplastic (Table 4)

These adhesives are based on thermoplastic resins (including asphalt and oleoresin adhesives) dissolved in solvent or emulsified in water. They can be softened or melted, often repeatedly, by heating, and then hardened by lowering the temperature. (They are characterized by low molecular weight with a minimum number of chemical cross-linkages.) Most of them become brittle at subzero temperatures and may not be used under stress at temperatures much above 150 F.

Because of their relative softness, thermoplastic adhesives exhibit poor creep strength. Thus, although they may test stronger than a thermoset adhesive initially, such superiority will not hold under a static load as time passes. This weakness must be compensated for by incorporating into the design, wherever possible, caps, folded overlaps or rivet stiffeners. Although lower in strength than all but natural adhesives, and suitable only for mild service, they are also lower in cost and are used fairly extensively. They have the advantage of being odorless and tasteless, and can be made fungus resistant.

Thermoplastic adhesive bonds are

TABLE 3—ADHESIVES CLASSIFIED BY CHEMICAL COMPOSITION

Group →	Natural	Thermoplastic	Thermosetting	Elastomeric	Alloys[a]
Types Within Group	Casein, blood albumin, hide, bone, fish, starch (plain and modified); rosin, shellac, asphalt; inorganic (sodium silicate, litharge-glycerin)	Polyvinyl acetate, polyvinyl alcohol, acrylic, cellulose nitrate, asphalt, oleoresin	Phenolic, resorcinol, phenol-resorcinol, epoxy, epoxy-phenolic, urea, melamine, alkyd	Natural rubber, reclaim rubber, butadiene-styrene (GR-S), neoprene, acrylonitrile-butadiene (Buna-N), silicone	Phenolic-polyvinyl butyral, phenolic-polyvinyl formal, phenolic-neoprene rubber, phenolic-nitrile rubber, modified epoxy
Most Used Form	Liquid, powder	Liquid, some dry film	Liquid, but all forms common	Liquid, some film	Liquid, paste, film
Common Further Classifications	By vehicle (water emulsion is most common but many types are solvent dispersions)	By vehicle (most are solvent dispersions or water emulsions)	By cure requirements (heat and/or pressure most common but some are catalyst types)	By cure requirements (all are common); also by vehicle (most are solvent dispersions or water emulsions)	By cure requirements (usually heat and pressure except some epoxy types); by vehicle (most are solvent dispersions or 100% solids); and by type of adherends or end-service conditions
Bond Characteristics	Wide range, but generally low strength; good res to heat, chemicals; poor moisture res	Good to 150-200 F; poor creep strength; fair peel strength	Good to 200-500 F; good creep strength; fair peel strength	Good to 150-400 F; never melt completely; low strength; high flexibility	Balanced combination of properties of other chemical groups depending on formulation; generally higher strength over wider temp range
Major Type of Use[b]	Household, general purpose, quick set, long shelf life	Unstressed joints; designs with caps, overlaps, stiffeners	Stressed joints at slightly elevated temp	Unstressed joints on lightweight materials; joints in flexure	Where highest and strictest end-service conditions must be met; sometimes regardless of cost, as military uses
Materials Most Commonly Bonded	Wood (furniture), paper, cork, liners, packaging (food), textiles, some metals and plastics. Industrial uses giving way to other groups	Formulation range covers all materials, but emphasis on nonmetallics—esp wood, leather, cork, paper, etc.	Epoxy-phenolics for structural uses of most materials; others mainly for wood; alkyds for laminations; most epoxies are modified (alloys)	Few used "straight" for rubber, fabric, foil, paper, leather, plastics films; also as tapes. Most modified with synthetic resins	Metals, ceramics, glass, thermosetting plastics; nature of adherends often not as vital as design or end-service conditions (i.e., high strength, temp)

[a] "Alloy," as used here, refers to formulations containing resins from two or more *different* chemical groups. There are also formulations which benefit from compounding two resin types from the same chemical group (e.g., epoxy-phenolic).

[b] Although some uses of the "nonalloyed" adhesives absorb a large percentage of the quantity of adhesives sold, the uses are narrow in scope; from the standpoint of diversified applications, by far the most important use of any group is the forming of adhesive alloys.

TABLE 4—SOME TYPES OF THERMOPLASTIC ADHESIVES

Type ↓	Description	Outstanding Characteristics	Usual Adherends	Typical Uses
Polyvinyl Acetate	Solvent solutions and water emulsions, plasticized or unplasticized, often containing fillers and pigments. Also dried film which is light-stable, water-white, transparent	Bond strength of several thousand psi but not under continuous loading. The most versatile in terms of formulations and uses. Tasteless, odorless; good res to oil, grease, acid; fair water res	Emulsions particularly useful with porous materials like wood and paper. Solutions used with plastics films, mica, glass, metal, ceramics	Paper containers, shoes, furniture, laminates of paper to metal foil or plastics films
Polyvinyl Alcohol	Water solutions, often extended with starch or clay	Odorless, tasteless and fungus-resistant (if desired). Excellent resistance to grease and oils	Porous materials such as fiberboard, paper, cloth	Packaging, particularly for foods
Vinyl-Vinylidene	Solutions in solvents like methyl ethyl ketone	Tough, strong, transparent and colorless. Res to hydrocarbon solvents, greases, oils	Particularly useful with textiles; also porous materials, plastics	Where transparent film is required with chem res
Acrylics	Solvent solutions, emulsions and mixtures requiring added catalysts	Wide range of properties; transparent with good weathering and sunlight res	Plastics	Radomes; glass fiber-reinforced polyester sheets for awnings, roofings, etc.
Oleoresin	Solvent solutions with vegetable oil and rosin or phenolic resins	Excellent tack and high immediate strength. Softened by common solvents. Not subject to damage by freezing. Low creep strength	Tiles, wallboard	Wall and ceiling tiles; wallboard
Asphalt	Solvent solutions (cut-backs), water emulsions	Excellent water and alkali resistance; low bond strength	Glass, metal, concrete, paper, felt	Installation of asphalt floor tile, linoleum

TABLE 5—SOME TYPES OF ELASTROMERIC ADHESIVES

Type ↓	Description	Outstanding Characteristics	Usual Adherends	Typical Uses[a]
Natural Rubber	Solvent solutions, latexes and vulcanizing types which cure by heat or at rm temp (two-part)	Excellent tack, good strength. Shear strength 30-180 psi; peel strength 0.56 lb/in. width. Surface can be tack-free to touch and yet bond to similarly coated surface	Natural rubber, masonite, wood, felt, fabric and paper to each other and to metal	Pressure sensitive tapes, fabrics, paper
Reclaimed Rubber	Solvent solutions, some water dispersions. Most are black, some gray and red	Low cost, widely used. Peel strength higher than natural rubber; failure occurs under relatively low constant loads	Rubber, sponge rubber, fabric, leather, wood, metal, painted metal	Sponge rubber and felt to metal and to wood, as for step treads on ladders, stairs, etc.
Styrene-Butadiene	Solvent solutions and latexes. Because tack is low, rubber resin is compounded with tackifiers and plasticizing oils	Usually better aging properties than natural or reclaimed. Low dead load strength; bond strength similar to reclaimed. Useful temp range from −40 to 160 F	Fabrics, foils, plastics film laminates, rubber and sponge rubber, wood	Floor and wall coverings, foil-paper laminates, labels
Neoprene	Latexes and solvent solutions, often compounded with resins, metallic oxides, fillers, etc.	Superior to other rubber adhesives in most respects—quickness; strength; max temp (to 200 F, sometimes 350 F); aging; res to light, weathering, mild acids and oils	Metals, leather, fabric, plastics, rubber (particularly neoprene)	Laminates, sandwich structures, weatherstripping
Nitrile	Latexes and solvent solutions compounded with resins, metallic oxides, fillers, etc.	Most versatile rubber adhesive. Superior res to oil and hydrocarbon solvents. Inferior in tack range; but most dry tack-free, an advantage in precoated assemblies. Shear strength of 150-2000 psi, higher than neoprene if cured	Rubber (particularly nitrile), metal, vinyl plastics	Laminating and installing flexible materials
Silicone	Solvent solution: heat or rm-temp-curing and pressure sensitive. Also heat-vulcanizing solventless pastes	Of primary interest is pressure sensitive type used for tape and still in development stage. High strengths for other forms are reported from −100 to 500 F; limited service to 700 F. Excellent dielectric properties	Metals; glass; paper; plastics and rubber, including silicone and butyl rubber and fluorocarbons	Aircraft and electronic industries; fabricating complex silicone rubber parts

[a] "Straight" elastomeric adhesives have extremely narrow use; in most applications they are compounded with other resins to form adhesive alloys. Thus this table is primarily an indication of the characteristics furnished by the elastomeric portion of an adhesive alloy.

TABLE 6—SOME TYPES OF THERMOSETTING ADHESIVES[a]

Type ↓	Description	Outstanding Characteristics	Usual Adherends	Typical Uses
Phenolic (phenol formaldehyde)	Available as solutions in alcohol, acetone or water; as powders, and as films. Require heat and pressure to cure	High adhesion to many difficult-to-bond materials such as metals and glass. Good creep strength and poor to fair peel strength from −30 F to 200 F	Metal, glass, plywood, other wood products	Plywood, light bulbs and radio tubes to metal bases
Resorcinol & Phenol Resorcinol	Usually alcohol-water solutions to which formaldehyde must be added. Cure at rm temp or higher with moderate pressure	Suitable for exterior use; unaffected by boiling water, mold, fungus, grease, oil, most solvents. Bond strength equals or betters strength of wood; do not bond directly to metal	Wood, plastics, paper, textiles, fiberboard	Plywood, marine applications
Urea Formaldehyde	Usually supplied as two-part resin and hardening agent. Extenders and fillers used. Cure under pressure	Not as durable as others but suitable for fair range of service conditions. Generally low cost and ease of application and cure. Pot life limited to 1 to 24 hr	Chiefly plywood	Plywood
Melamine Formaldehyde	Powder to be mixed with hardening agent. Cure with heat and pressure	Equivalent in durability and water resistance (including boiling water) to phenolics and resorcinols. Often combined with ureas to lower cost. Higher service temp than ureas	Plywood, other woods	Plywood, wood products, furniture
Polyester	Two-part adhesive with no solvent release occurring	Res to chemicals, moisture, heat, weathering. Good electrical properties; wide range of strengths	Metals, foils, plastics	Polyester laminates

[a]Epoxies are discussed as 100% solids structural adhesives (see text and Tables 7 and 8). However, some special purpose types are available as low-viscosity liquid adhesives containing solvents.

generally accomplished by cold setting. This means that both surfaces are coated, partially dried and then pressed together. The method is not suitable for two nonporous surfaces, as remaining solvent cannot escape. In some cases the adhesive coats are dried before assembly and reactivated later by heat.

3. Elastomeric (Table 5)

These adhesives are based on natural and synthetic rubbers and are available as solvent dispersions, latexes or water dispersions. They are mostly used as compounds which have been modified with resins to form some of the adhesive alloys to be discussed later. They are similar to thermoplastics in that they soften with heat, but they never melt completely. It is difficult to summarize their characteristics, as rubbers differ widely from one another in such properties as oil resistance, strength, tack and resistance to aging. They do have high flexibility and very low strength and, without resin modifiers, are used to bond paper and similar materials.

4. Thermosetting (Table 6)

These adhesives are based on thermosetting resins (many adhesive *alloys* behave so similarly to thermosetting adhesives that they are loosely given this designation, but this practice is not followed here). Thermosetting adhesives soften with heat only long enough for the cure to start. Upon completion of the curing reaction they remain hardened and cannot be decomposed. Although most of this group does not decompose at temperatures below 500 F, some are useful only to 150 F. Different chemical types have different cure requirements, some being supplied as two-part adhesives and mixed before use at room temperature, and some requiring heat and/or pressure.

This group provides stronger bonds than the three groups previously discussed. Creep strength is good and peel strength fair, but the bonds are brittle and have little resiliency and low impact strength.

5. Alloys

"Alloys," as used here, refer to adhesives that are compounded from resins of two different chemical groups. They are thus termed thermoset-thermoplastic or thermoset-elastomer adhesives. (Industry practice sometimes refers to the former type as thermosetting and the latter type as thermosetting-thermoplastic, a distinction based on cure requirements and behavior rather than composition.)

The reason for alloys is that the thermosetting resin is plasticized by the second resin, thereby becoming tougher, more flexible and more resistant to impact. As might be supposed, a wide range of properties can be obtained by combining different resins, and even by developing different formulations using the same resins.

When the second resin is thermoplastic, the adhesive cures and behaves in a manner very similar to that of straight thermosetting adhesives, with the additional advantages noted above.

When the second resin is elastomeric, the bonds are semi-rigid and shear strengths are slightly lower than for other alloys. Peel strength is fairly good and flexibility is fair. A big advantage lies in the ease of use; unlike most other alloys they require little or no heat to complete the bond.

text continues on p 122

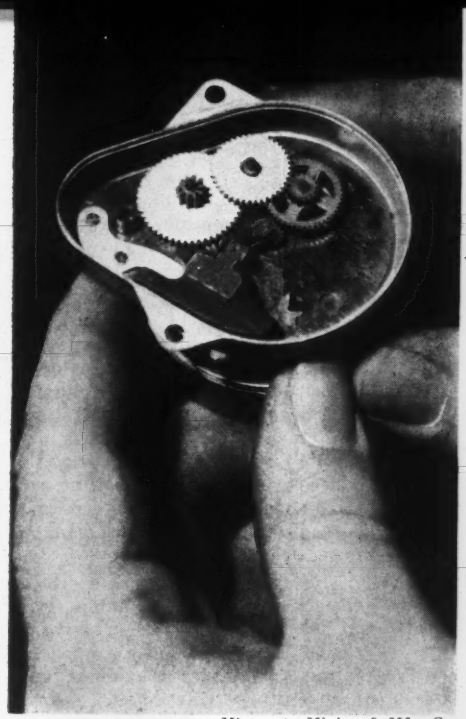
8 uses show many advantages of adhesive bonding

Dissimilar materials joined — *Radiation monitoring dosimeter pen uses quartz fiber bonded to aluminum wire.*

Eastman Chemical Products, Inc.

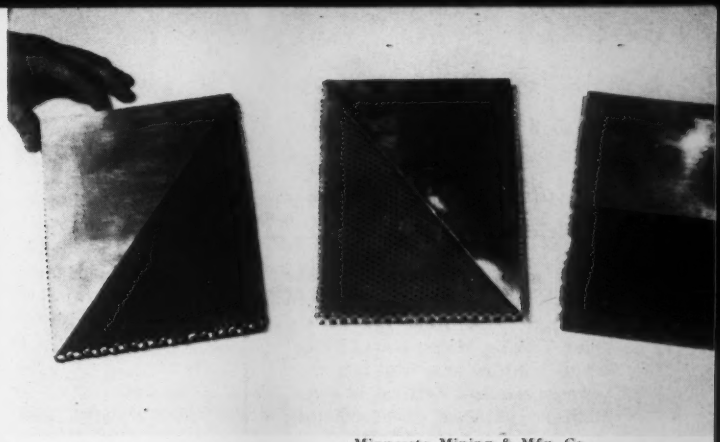
Rubber & Asbestos Corp.

Liquid seals—*Plastics astrodome is constructed of bonded styrene foam blocks.*



Minnesota Mining & Mfg. Co.

Cost reduction—*Timing motor pinions are now bonded, instead of brazed, to rotor shaft.*

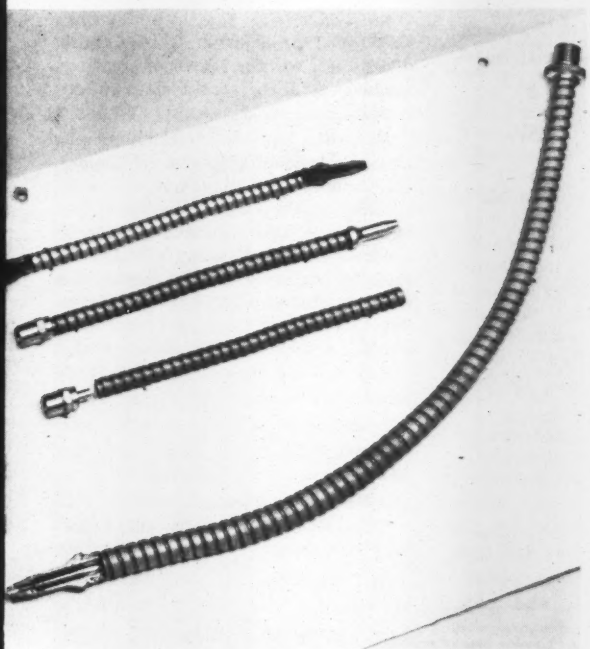


Minnesota Mining & Mfg. Co.

Loads uniformly distributed—*Sandwich panels may use (left to right) film, self-filletting or contact-bond adhesives.*

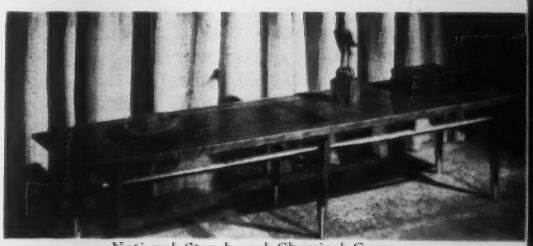
Minnesota Mining & Mfg. Co.

Vibration resistance—*Air motor rotor end plates are made by joining powdered iron disk to aluminum casting with die-cut adhesive film.*



Minnesota Mining & Mfg. Co.

Design simplification—*End connectors are joined to flexible steel tubing with modified epoxy adhesive.*

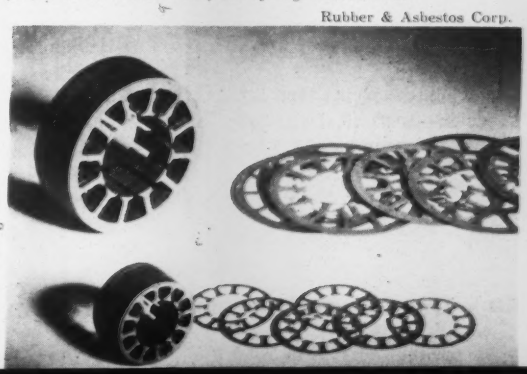


National Starch and Chemical Corp.

Smoothly contoured appearance — *Furniture depends highly on many types of adhesives for durability, economy and attractive appearance.*

Electrical Insulation—*Metal motor laminations are fabricated with modified epoxy adhesives.*

Rubber & Asbestos Corp.



Adhesive Bond Tests and Standards

A number of standard tests for adhesive bonds have been defined by the American Society for Testing Materials (ASTM), and military specifications exist for specialized testing of structural adhesives. Nevertheless, lack of methods for satisfactory evaluation of bond properties on a production basis remains one of the drawbacks of adhesive bonding.

The property usually reported by adhesive suppliers, determined in general screening tests, is tensile shear strength at normal or elevated temperatures. Specific strength values for test specimens cannot be readily translated to other geometries or areas. In addition, strengths determined by short-time tests do not give an indication of behavior under either continuous stress or different environmental conditions.

Present methods of quality control of bonded parts depend highly on statistical analysis of results obtained from destructive testing. Ultrasonic and special equipment is used in some cases, but until a satisfactory method of nondestructive testing has been developed for rapid and general use, quality will actually remain under the control of the personnel applying and curing the adhesives.

The ASTM has established *Committee D-14 on Adhesives* to study these problems. Following are the common ASTM test specifications presently applied to adhesive bonds:

Cleavage—D1062-51.
Definitions (adhesive)—D907-55.
Flexure—D1184-55, C393-57T.
Impact—D950-54.
Peel or stripping—D903-49, D-14T.
Shear (tensile loading)—D1002-53T.
Shear (compressive loading)—D905-49.
Tack range—D1144-51T.
Tension—D897-49, D429-56T.
Thermal cycling—D1183-55T, D1057-56T.

'Structural' adhesives

The term "structural" is intended to imply that the adhesive contributes to the load-bearing properties of the bonded assembly. At best it is a relative term, and there are adhesives in every chemical group which, in some applications, may be termed "structural." But the term has been generally applied to the thermosetting adhesives, some of the elastomeric adhesives, and the adhesive alloys.

Now, however, with the increased demands sparked by the aircraft and missile fields, "structural" is beginning to mean those adhesive alloys which possess the ultimate strength properties (although still a compromise between shear and peel strengths), often at extended temperature ranges and particularly when used with metals and rigid structural plastics. There is much research and development under way in this area—and much of it has yet to be reported and make its way into commercial markets—but at present there are two main classes in substantial usage. These are the modified epoxies and the phenolic alloys. Because the outstanding quality of the epoxies is that they contain no solvents, these two classes are also referred to as "solvent dispersions" (phenolic alloys) and "100% solids" (modified epoxies).

Table 7 considers those characteristics which can be related solely to the vehicle which transports the adhesive system, without regard to properties obtained because of the chemical nature. Other solvent-dispersed alloys have been produced, or are being studied—notably the epoxies and alkyds. As for 100% solids, the phenolics appear to be limited in flexibility, and to require heat and pressure to achieve high strength. Other systems under research investigation include silicones, monomer-hardener systems and isocyanate-alkyds.

The 100%-solids modified epoxies are here termed "alloys" although the word is not usually applied to them in practice. An extremely wide range of formulations is obtained by the use of polymeric hardeners (such as polyamides and polyamines, phenolics, isocyanates, alkyds and polysulfide-amine combinations) or by alloying with compatible polymeric film-formers (such as polyvinyl acetate and certain elastomers).

"Structural adhesives" may now, therefore, be considered to refer to such alloys as the following commonly used types (see also Table 8):

1. Vinyl formal-phenolic

The properties of this type fall between those of the modified epoxies and the thermoset-elastomer types. Vinyl formal-phenolic adhesives have "good" shear, peel, fatigue and creep strength properties and "good" resistance to heat, though the adhesive softens somewhat at elevated temperatures. Tensile strengths depend on the metal bonded, ranging from 1000 to 4000 psi.

This type is supplied as a solvent dispersion in solution or in film form. In the film form the adhesive is coated on both sides of a reinforcing fabric. Sometimes the adhesive is prepared by mixing a liquid phenolic resin with vinyl formal powder just prior to use.

Before bonding, the liquid type must be air dried and then force dried at 150 to 180 F for about 30 min to reduce the amount of volatile material given off during cure. In some cases forced drying also improves strength properties.

Final curing is the same for film and liquid. Required pressures range from 50 to 150 psi and temperatures from 240 to 325 F. Optimum film thickness varies from 2 to 6 mils depending on the type of mating surfaces and the stress distribution needed.

Butyral type—A second vinyl-phenolic type of adhesive of importance consists of vinyl butyral resin modified with phenolic resins. This type is widely used in sandwich panel construction for bonding metals and high pressure laminate facings to resin-treated paper honeycomb cores. The adhesive has high room-temperature shear and peel strengths which fall off at high temperatures more rapidly than the strengths of comparable bonds made with the less thermoplastic vinyl formal-phenolic adhesive.

2. Neoprene-phenolic

This type is generally characterized by excellent peel strength, and shear strength that, though higher than for the thermoset-thermoplastic type, is not as good as that of the modified epoxies, particularly at higher temperatures. Neoprene-phenolics offer good flexibility and

vibration absorption, and have good adhesion to most metals and plastics.

They are particularly suited to the joining of thin metal sheets to themselves or to supporting structures. They may be used in honeycomb construction if a special effort is made to physically form a fillet between the honeycomb and skin, but the adhesives do not self-fillet.

These adhesives are usually moderately priced. Most are solvent types, but special two-part chemically curing types are sometimes used to obtain specific properties.

Heat curing types in dry film form are also available and are compounded to have higher strength and heat resistance. These types are usually semi-rigid. There is some elasticity and elongation, and as a result the adhesive layer will stretch or give slightly under stress. This property allows stress equalization and gives the adhesive excellent resistance to fatigue and peelback. Heat cured neoprene-phenolic dry film adhesives range in shear and tensile strengths from about 1800 psi to 5000 psi. Strength at 180 F is generally half that at room temperature.

Here, again, other types of thermoset-elastomer adhesives are in use. One in particular, nitrile-phenolic, is frequently replacing both the vinyl-phenolic and neoprene-phenolic types. Nitrile-phenolic adhesives have a broader range of properties, superior flexibility, better salt spray resistance and a higher service temperature range. Some formulations are suitable at –80 F but shear strength and impact resistance are considerably reduced. Most formulations can be used for continuous service at 250 F, and some films will withstand moderate stress at temperatures as high as 500 or 600 F for short periods.

3. Modified epoxies

Modified epoxies are broadly divided into two types: those that cure at room temperature by the addition of a chemical activator (two-part), and those that cure under heat (either two-part or one-part to which a latent catalyst was added at the time of manufacture). Heat curing formulations have higher strengths than room-temperature-curing types and maintain their strength over a wider temperature range (to 150-180 F for room tem-

TABLE 7—VEHICLE DESIGNATIONS OF HIGH-STRENGTH STRUCTURAL ADHESIVE ALLOYS[a]

Type	Solvent Dispersed	100% Solids
Form	Liquids; some pastes	Liquids, pastes, films, powders
Alloy	Elastomeric[b] or thermoplastic[c] resin + thermosetting resin	Modified epoxies
Cure Requirements	Usually pressure and either heat or solvent (reactivation type)	Contact or light pressure. Choice of rm-temp (two-part) or heat curing (one-part) types
Advantages	Flowability; easy to apply in both forms with all types of equipment. Can be heat or solvent reactivated. Allows wide choice of formulations. Usually lower cost.	No time wait for solvent release; no difficulty in bonding nonporous surfaces; no attack on vulnerable adherends. Eliminates fire hazard. Fills voids.
Limitations	Care must be taken to allow for solvent release if both surfaces are nonporous (not usually recommended). Solvent may interact unfavorably with certain plastics and rubbers	More common rm temp-type is supplied as two-part adhesive requiring metering and mixing; working life limited. Some formulations fairly expensive

[a]Some structural adhesives are water emulsions or latexes but these are not generally of the highest strength.
[b]Generally neoprene or nitrile rubber. [c]Generally polyvinyl formal or-polyvinyl butyral.

TABLE 8—PROPERTIES OF SOME TYPES OF STRUCTURAL ADHESIVES

Type ➡	Modified Epoxies		Phenolic-Elastomeric[a]	Phenolic-Thermoplastic[b]
	Rm Temp Cured	Heat Cured		
CURING PROCEDURE				
Temperature, F	70-90	320-500	300-400	250-350
Pressure, psi	Contact	Contact	25-200	50-200
Time, min	1-7 days	2-60	2-60	30-120
MECHANICAL PROPERTIES				
Shear Strength, psi				
—65 F	350-2500	1300-5000	3500-4500	2000-3000
68 F	2500-4200	3000-5000	2000-6000	2500-5000
180 F	180-900	2600-5000	1500-2800	800-4000
250 F	—	800-3600	500-2500	100-1800
300 F	–	450-3200	400-2220	100-1200
350 F[c]	—	200-1900	300-1700	100-500
Creep Strength[d]				
Room Temp	Excellent	Excellent	Good	Excellent
Elev Temp	Poor	Good[e]	Good	Good[e]
Peel Strength	Poor	Poor	Excellent	Fair-good
Flexibility	Poor	Poor	Excellent	Fair-good
CHEMICAL RESISTANCE				
Water	Fair[f]	Excellent	Good	Excellent
100% Humidity	Fair[f]	Excellent	Good	Excellent
Salt Spray	Poor[f]	Excellent	Good	Excellent
Oils	Excellent	Excellent	Good	Excellent
Glycols	Good[f]	Good	Good	Excellent
Fuels	Excellent	Excellent	Good	Excellent

[a]Based on nitrile-phenolics.
[b]Based on vinyl-phenolics.
[c]Upper temperature limit of continuous service is now 500 F for epoxies.
[d]Creep strength and dead-load strength.
[e]To limiting temperatures.
[f]Rating can be "Excellent" if proper primer is used.

perature type, 350 F and up for heat curing type, depending on type of load). Postcuring the room temperature type for 30 to 60 min at 200 F improves the strength properties, particularly at the higher temperatures.

The pot life of the one-part type is unlimited; that of the two-part types ranges from 15 min to 24 hr or more. Some two-part room-temperature-curing formulations may reach 85% of ultimate strength within 4 to 6 hr, but usually a setting time of 4 to 6 days is required. Cure times for the heat curing type range from 60-90 min at 320-350 F to 1½ min at 500 F, but care is required to prevent overcuring. In most cases, only contact or low pressure is needed during the cure cycle.

Epoxy adhesives of either type are excellent for metal-to-metal bonding and for honeycomb sandwich construction. Because they are 100% solids, there is no problem of solvent evaporation after joining impervious surfaces. Other advantages include: very high shear strength and rigidity, excellent self-filleting, and excellent wetting of metal and glass surfaces. In general, the adhesives resist most solvents, mild acids and mild alkalis.

Major disadvantages are low peel strength, lack of flexibility and inability to withstand high impact. Epoxy adhesives cost somewhat more than most other types.

The Seven Steps in Adhesive Bonding

The steps necessary to achieve an adhesive bonded assembly may include the following:

1. Prepare the surfaces Both surfaces must be clean and dry. Special care must be taken with metals; they must be degreased, lightly abraded or chemically cleaned, thoroughly dusted and dried. Particular chemicals and procedures are recommended depending on the metals or alloys involved. Plastics and rubber often require the removal of plasticizer bloom or mold release agents. Some plastics, such as polyethylene or fluorocarbons, require additional chemical treatments (or purchase of "bondable" grades) to make the adhesive stick. Most industrial adhesives bond well to paint, lacquer, anodize and other surface finishes if the finish is clean and well anchored to the adherend material.

2. Prepare the adhesive The adhesive must be brought to the prescribed application temperature—usually room temperature but sometimes higher. Some liquid adhesives must be thinned by solvents; others may be supplied as a powder requiring premixing with water or solvent. Some adhesive alloys may be supplied as two liquid components requiring mixing together. Room-temperature-curing types may require the addition of a catalytic agent (the term "two-part adhesive" is usually reserved for this type). Some elastomeric adhesives may require the addition of a vulcanizing agent. Metering-mixing-dispensing pumps are available for some of these mixing tasks. Pressure sensitive tapes must have the backing stripped away. Other films and tapes may require reactivation by brushing or spraying with water, solvent or wet adhesive, instead of by heat.

3. Apply the adhesive The form of the adhesive (trowelable mastic, film, supported tape) may determine an obvious method of application. Liquid adhesives may be applied by a variety of methods: Brush coating is widely used; though inexact and slow, it is suitable for the type of bonding required by a vast number of applications. Roller coating is fast and economical where continuous production of sheets or rolls of one thickness is involved. Extrusion guns and flow brushes (hollow tube and brushes through which adhesive is fed by air pressure) are suitable for jobs where a bead or ribbon of adhesive must be accurately placed. Dipping is of particular value where large areas of multiple laminations require relatively thin films of adhesive. Silk screening is for specialized applications using low viscosity adhesives and relatively thin films; spraying, when possible, is particularly suitable for large area coverage and mass production.

4. Dry the adhesive coating The degree of drying before assembly may vary from none at all through various degrees of solvent evaporation to complete drying for later reactivation by solvent, heat or pressure. Drying may be done at room temperature with or without forced drafts, or by warm air flow, infrared lamps or hot plates. Drying is particularly important when using solvent-dispersed adhesives to bond nonporous surfaces.

5. Apply pressure Pressure may vary from contact or light pressure applied by hand, by weights, or by clamps and wedges, to pressures of 100 to 500 psi (250-350 psi is usual average for non-epoxy structural adhesives) applied by hydraulic pads, cylinders and hydraulic presses, and occasionally by autoclaves and vacuum bags.

6. Apply heat Most room-temperature-curing adhesives gain added strength when postcured at temperatures up to 200 F. Some adhesives require cure temperatures as high as 500 F, though the usual range for structural adhesives is 250-350 F. Heat may be applied by numerous methods, including those listed under No. 4 above as well as: hot water, steam, hot oil bath, dielectric or induction methods, electric resistance, and the common technique of oven heating which is usually adaptable to the simultaneous application of pressure.

7. Develop full bond strength This is a matter of time. Most adhesives develop full strength either within minutes or, at most, within a few hours. Some, however, require weeks to develop full strength.

Joint design

Designing for adhesive bonding is largely a matter of common sense. Two fundamentals should be observed:

1. Put the maximum amount of bonded area to work.

2. Use favorable geometry for the joint design.

Maximum area

The four basic types (Fig 1) of stress encountered in structural bonding are: tensile, sheer, cleavage and peel. These stresses illustrate the first fundamental.

In *tensile* loading, the forces are perpendicular to the plane of the joint and forces are thus uniformly distributed over the entire area. The entire joint is under stress at the same moment and all of the adhesive is at work at the same time. No portion of the joint is carrying more or less than its share of the load.

In *shear* loading, the stress is also distributed uniformly over the entire joint and all of the adhesive is put to work at the same time. However, in shear loading, the stress is parallel to the plane of the joint. This type of joint is most frequently used because it is more practical to accomplish.

In *cleavage* loading, not all of the adhesive is at work at the same time. As force is applied, one side of the joint is under great stress while the other is under no load at all. This type of joint cannot be as strong as a joint of comparable area under tensile or shear loading and therefore should be avoided.

In *peel* loading, the stress is confined to a very fine line at the edge of the joint. In this case, even less of the adhesive contributes to strength than in the cleavage joint. Most of the adhesive is under no load and only a portion of the adhesive is at work. Even more than cleavage, this joint design should be avoided.

Joint geometry

Joint design is usually more complicated than indicated above; rarely, if ever, will a joint be subjected to only one stress. In practice, there is usually a combination of several different types of stresses. In some cases, distortion of adherends under load (see Fig 2 on this page) will introduce secondary stresses. In these cases the second fundamental, favorable joint geometry, becomes important. Following are the typical joints used in adhesive bonding:

Lap joints—In adhesive joint design, the lap (or shear) joint will be the most frequently encountered. In the first place, most bonds involve thin gage materials and these are difficult to join by any design except the lap. Secondly, lap joints are quite practical and applicable to adhesive bonding.

However, because of the offset nature of lap joints, shear forces are not in line. This can result in the introduction of cleavage and peel stresses.

Under moderate load, distortion of the joint occurs because the bond area will pivot normal to the load. At this point, an element of cleavage is introduced. When an extreme load is applied, such that fatigue occurs, definite bending of the material at the edges of the bond takes place. Then peel stresses are introduced. Thus, material distortion results in secondary stresses.

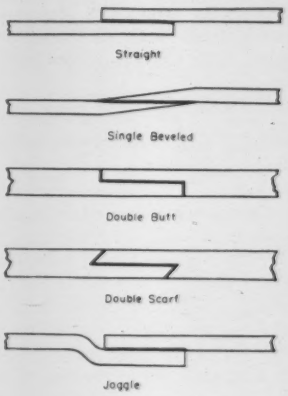
In these cases, the joint should be redesigned for maximum strength. The three alternatives:

1. The joint can be redesigned to bring the load on the adherends in line.

2. The adherends can be made more rigid near the bond area to minimize cleavage.

3. The edges of the bond area can be made more flexible for better conformance, thus minimizing peel.

A beveled single-lap joint is more efficient than a straight lap joint.



Lap joints

The beveled edge allows bending of the joint edge when distortion occurs under stress.

The double-butt lap joint places the adhesive line in the same plane as the shear stress on the adherends. This type of joint, however, requires machining which is not always feasible with thin-gage materials.

Double-scarf lap joints have better resistance to bending forces than double-butt lap joints. This type of joint, however, also presents machining problems.

The joggle lap joint seems to be the most practical. It places the

***Fig 1**—Four basic types of stress encountered in structural bonding. Greatest strength is obtained when maximum area is used, as in tensile or shear loading.*

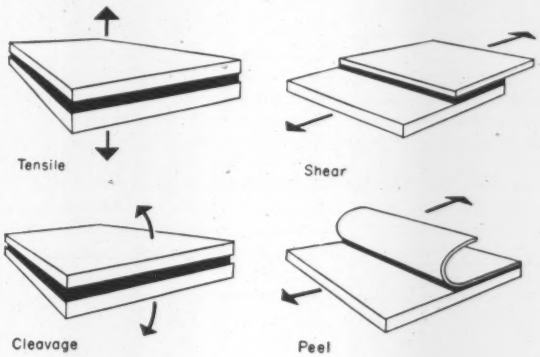
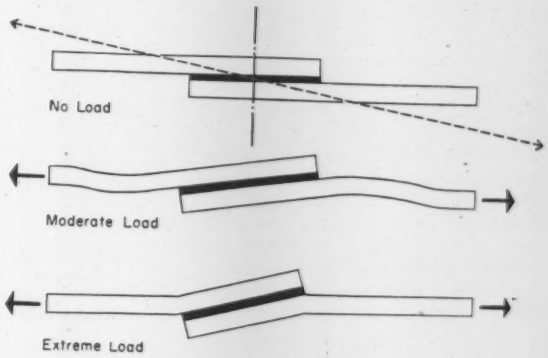
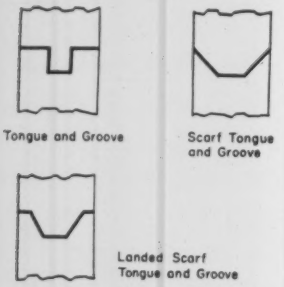


***Fig 2**—Distortion caused by loading can introduce secondary stresses and must be considered in joint design.*



adhesive line in the same plane as the shear stress on the adherends. In this type of joint, application of pressure for curing is easily accomplished and the joint can be formed by simple operations.

Butt joints—A straight butt joint is weak in cleavage. In the case where two flat, rigid rod ends are butt-joined with an adhesive, any bending of the rods can, through leverage, exert tremendous cleavage forces on the joint. For this reason, recessed joints such as landed scarf tongue and groove, conventional

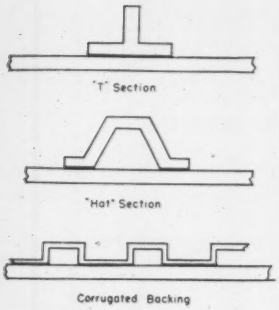


Butt joints

tongue and groove, and scarf tongue and groove are recommended. However, joints must have adequate clearance to facilitate machining and assembling operations. Thus, adhesives with void-filling properties are required for butt joint assembly.

Landed scarf tongue and groove joints have the advantage of acting as stops which can be utilized to control the adhesive line thickness. Scarf tongue and groove joints, on the other hand, make assembly easier in that self-aligning takes place when tongue and groove are joined.

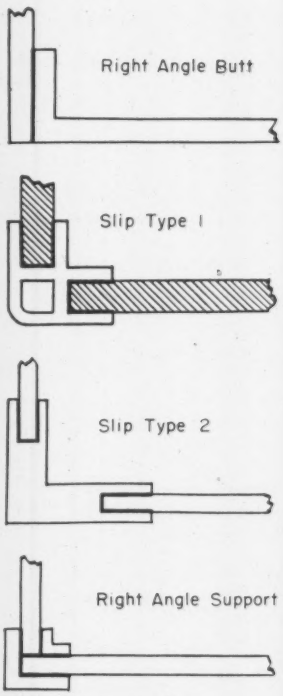
Stiffener joints—Where large areas of thin gage materials are used, problems of "oil canning," waviness and flutter are usually encountered. Stiffening of such surfaces is usually desired and can be efficiently and economically accomplished by adhesive bonding stiffening members to the large areas. In attachment of stiffening members to thin metal sheets, common in aircraft construction, the sheets deflect in service and peel stresses are exerted on the adhesives. If the flanges on the stiffening section can deflect with the sheet, minimum difficulty from peel will result. Either increasing the stiffness of the sheet or reducing the stiffness of the flange on the stiffening section will result in improvement.



Stiffener joints

Several types of stiffening members such as T-sections, hat sections and corrugated backing are commonly used. T-sections are simple. Hat sections are more commonly used and have excellent rigidity. Corrugated backing results in excellent flatness over entire area.

Light corner joints—By some joint redesign, it is possible to adhesive bond the corners of products made of light gage steel or cored sandwich panels. The usual right-angle butt joint used for mechanical attaching is not applicable for adhesive bonding; it produces either cleavage or peel stresses. The use



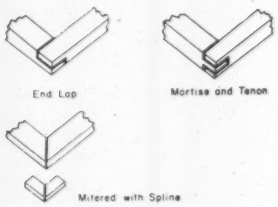
Light corner joints

of supplementary corner reinforcement attachments, however, permits adhesive bonding and also seals the joint. Typical designs for adhesive bonding are slip and right-angle support joints. These joints also give the resultant structure an increased degree of rigidity.

In a slip joint, use of a supplementary corner extrusion is best. The extrusion can be as heavy as the desired rigidity demands. The two edges of the part are bonded into the slip joint. The use of interior and exterior right angle supports is a variation from the slip joint. However, this method requires indexing fixtures until adhesive is cured.

Film adhesives for these applications are not too applicable because of the complicated pressure fixtures required. Adhesives with void-filling properties, such as epoxy types, are indicated. The possibility of using a heat-curing epoxy adhesive depends on the heat resistance of the components being bonded.

Rigid corner joints—These are encountered when joining rigid members, like storm doors or decorative frames, and can also be adhesive bonded. In these cases, butt joints would not be adequate for adhesives because of inherent racking or twisting stresses. In order to make available the required bond area to resist such stresses, woodworking adhesive



Rigid corner joints

joint design such as end lap, mortise and tenon, and mitered joint with spline, can be utilized.

End lap joints are simple but require machining. Adhesives requiring pressure could be utilized for this application. Mortise and tenon is an excellent type of joint but also requires machining. A mitered joint with spline should be considered if the members are hollow extrusions. The spline is usually die cast to loosely fit the interior of the extrusion. In this case, a void-filling adhesive is also indicated.

Where adhesive bonding is used

Applications of adhesive bonding encompass virtually every industry and thousands of products. Major use of adhesives is still in paper, packaging and woodworking, but usage has increased greatly in industrial plant equipment, transportation vehicles, construction, and particularly in military aircraft and missiles.

In the military field new formulations are constantly necessary, yet most find limited use before one project is completed and a new project again requires new formulations. Some formulations rapidly become obsolete; others await application in the commercial field.

Nonstructural uses

A survey of all products, or even industries, that use adhesives is impossible. This is particularly true of nonstructural adhesives. A few recent developments will illustrate the potential even though full discussion is impractical. A cigarette package, for example, may use nine different adhesives—and they may be different from those another package uses. Although choice is mainly a matter of production setups and application equipment, such factors as type of paper, coating, ink, etc. must be considered.

Here are some new applications, as well as old uses for which new adhesives have been developed.

Home and office: Vinyl wall coverings backed with pressure-sensitive adhesives; bonded desk and cabinet tops made of linoleum or plastics; bathroom tiles bonded to walls rapidly and cheaply; paint brush bristles bonded with chemical resistant adhesives; typewriters and other machines with sound-damping urethane foam bonded to metal.

Automotive: This industry is a large consumer of adhesives, some structural but most nonstructural. Nonstructural uses include such items as weather stripping and sound damping pads, but adhesives (particularly water emulsions for economy and safety) are also used in intermediate assembly steps to join parts temporarily. For example, one manufacturer bonds a spacer and two piston rings for ease of assembly; in operation, the engine oil dissolves the adhesive and the parts separate and function as intended.

Other industrial: Printshop engravings of metal or plastic bonded to mounting blocks; electron tube bases with nylon-to-metal bonds; printed circuits with copper bonded to an insulated base; fabrics constructed by bonding metallic coatings to woven yarns of synthetic fiber; packaging by bonding urethane foam to wood; blocks of foamed plastics bonded into intricate shapes formerly molded.

Structural uses

Most of the outstanding uses recently developed for adhesives are structural or semi-structural applications. Some of the following are extreme cases chosen to illustrate the potential of adhesive bonding.

Honeycomb and aircraft: Bonded honeycomb sandwich construction is used in many fields—locomotive panels, truck bodies, skyscraper curtain walls, desks, table tops and room

Some Basic Definitions

Adherend—A body held to another body by an adhesive.

Adhesion—The state in which two surfaces are held together by interfacial forces which may consist of valence forces, interlocking action, or both.

Adhesive—Substance capable of holding materials together by surface attachment.

Binder—Component of an adhesive composition which is primarily responsible for the adhesive forces which hold two bodies together.

Block, blocking—Undesired adhesion between adhesive-coated materials, such as may occur under moderate pressure in storage or during assembly.

Cohesion—The molecular attraction that holds together the particles of an adhesive.

Cold flow (creep)—The continuing dimensional change that follows initial instantaneous deformation in a nonrigid material under static load.

Condensation—Chemical reaction in which two or more molecules combine with separation of water or some other simple substance.

Contact bonding—Type of adhesive (particularly non-vulcanizing natural rubber adhesives), which bonds to itself on contact although solvent evaporation has left it dry to the touch.

Crazing—Fine cracks which may extend in a network on or under the surface of, or through a layer of, adhesive.

Cure—The chemical reaction that changes the physical properties of an adhesive film through polymerization, vulcanization or condensation.

Dispersion—Two-phase system in which one phase is suspended in liquid.

Dry—To change the physical state of an adhesive film by evaporation or absorption of the solvents.

Emulsion—A suspension of fine particles of a liquid in a normally incompatible liquid. By trade custom, the term "emulsion" is generally misapplied to dispersions, as in the case of asphalt "emulsions."

Faying surface—Surface of an object which comes in contact with another object to which it is fastened.

Glue—Originally, a hard gelatin obtained from animal hides, tendons, cartilage, bones, etc., or adhesive prepared from this substance by heating with water. Synonymous with "adhesive" only through general usage.

Glue line thickness—Thickness of the fully dried adhesive layer.

Latex—Fine particles of rubber suspended in water.

Lay down thickness—Thickness of the applied wet adhesive coating.

Long (long-bodied)—That type of adhesive texture which is very stringy, extensible, and not readily separable.

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dividers—but is most vital to aircraft and missiles. Skins generally consist of aluminum, magnesium or stainless steel; the cores of metal foil or reinforced plastics. Some sandwich panels or laminates are also fabricated with such materials as: porcelain enameled skins and fiberboard core; rigid plastics sheeting and steel; linoleum and steel; and porcelainized steel to paper or plywood.

The B-58 "Hustler," for example, uses over 800 lb of adhesives. Though not all of this amount is used in primary load-bearing structures, bonded sandwich panels do make up most of the wing and tail areas and much of the fuselage. Secondary structures include interior doors, storage cabinets, baggage racks, floor panels, partitions and cabin ceilings.

Adhesive films are used extensively to bond leading and trailing edges of helicopter rotor blades, and have also played an important role in the development of sealed, integral wing fuel tanks.

Automotive: Bonded brake bands, transmission bands and clutch facings are prime examples of structural applications. Structural uses will undoubtedly continue to increase, particularly with the increase in plastics components. Costs, production problems, and lack of adequate testing methods will probably prevent the development of the all-bonded car, although adhesives are available now which would meet end-service requirements.

Miscellaneous: Bonded inserts in reinforced plastics; chemical and petroleum industry equipment, particularly plastics lines and fittings; high-voltage oil circuit breakers; metal and ceramic tool bits to tool holders; ceramic coatings to engine parts; rubber to metal for such items as tires, motor mounts and vibration dampeners; bonding of magnet materials; high fidelity phonograph cartridges; cooling coils to evaporators of home freezers; plastics foams to metals and plastics for a variety of products; films and tapes for such specialized uses as splicing electrical cables in naval shipboard wiring and insulating electrical coils (fillers can also make adhesives bonds electrically conductive); tapes for masking off areas during chemical milling operations; parts for small products such as cameras, watches, electronic components and optical instruments; and, as a last example, the cementing of crowns and inlays onto teeth.

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Society of Automotive Engineers
Structural Adhesive Asso.
Westinghouse Electric Corp.
Wright Air Development Center

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Open time—The time interval either necessary or permissible between spreading the adhesive and assembling the parts for bonding.

Polymerization—Chemical reaction in which the molecules of a monomer are linked together to form large molecules whose molecular weight is a multiple of that of the original substance.

Pressure-sensitive—Type of adhesive which, after light, brief pressure, bonds to most surfaces for an almost unlimited time after drying.

Resin—Any of a class of solid or semisolid organic products of natural or synthetic origin, generally of high molecular weight with no definite melting point. Generally water-insoluble with little or no tendency to crystallize.

Set—To change an adhesive into a fully bonded state by either chemical or physical action.

Shelf life—The period of time a packaged adhesive can be stored under specified temperature conditions and remain suitable for use.

Short (short-bodied)—That type of adhesive texture which is of high viscosity but readily separable; buttery.

Sizing—Material, or process of applying material, used to fill pores on a surface and thus reduce absorption of a subsequently applied adhesive or otherwise modify properties of the adherend to improve adhesion.

Solids—Nonvolatile ingredients contained in an adhesive.

Spread—Quantity of adhesive per unit joint area applied to an adherend. *Single spread* refers to application to only one adherend of a joint; *double spread* to both adherends.

Stability—That property which allows an adhesive to be stored under specified conditions without loss of its original properties.

Tack—The sticky quality of an adhesive film either while wet or, with certain adhesives, after film has dried.

Tack range—The time during which an adhesive film remains tacky.

Thermoplastic—Capable of being repeatedly softened by heat and hardened by cooling.

Thermosetting—Having the property of undergoing a chemical reaction by the action of heat, catalysts, ultraviolet light, etc., leading to a relatively infusible state.

Viscosity—The resistance to flow offered by a liquid.

Vulcanization—Chemical reaction in which the physical properties of a rubber are changed in the direction of decreased plastic flow, less surface tackiness, and increased tensile strength.

Working life (pot life)—That period of time during which an adhesive remains workable after exposure to the air or after a two-part adhesive has been mixed.

Reprints of this Manual are available at 35¢ each until supply is exhausted. Turn to p 180 for complete list of available Manuals. Write for quotations on quantities of 100 or more. Address Reader Service Dept., MATERIALS IN DESIGN ENGINEERING, *430 Park Ave., New York 22, N. Y.*

first in silicones

Dow Corning

SILICONE NEWS

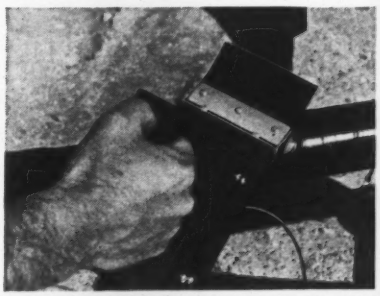
for design and development engineers • No. 66

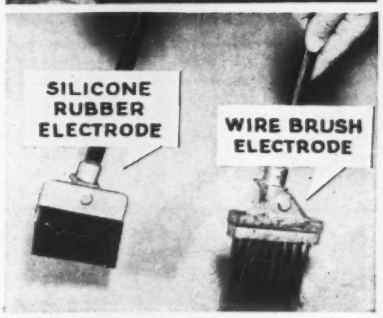
IMPROVE PERFORMANCE; INCREASE SERVICE LIFE

By ingenious use of Silastic®, the Dow Corning silicone rubber, Tinker and Rasor, San Gabriel, California, has made the first major improvement in 20 years in flat electrodes used for holiday or coating flaw detectors.

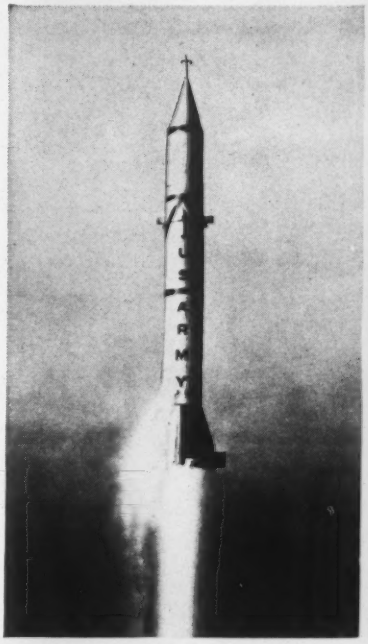
Designed to reveal pin holes, perforations and bare spots in painted, coated, taped or wrapped surfaces, holiday detectors signal where repairs must be made before extensive damage is done. The operator simply passes the unit's electrode over the protected surface, maintaining intimate contact. When a break in the surface is encountered, the detector converts electrical contact to an audible signal.

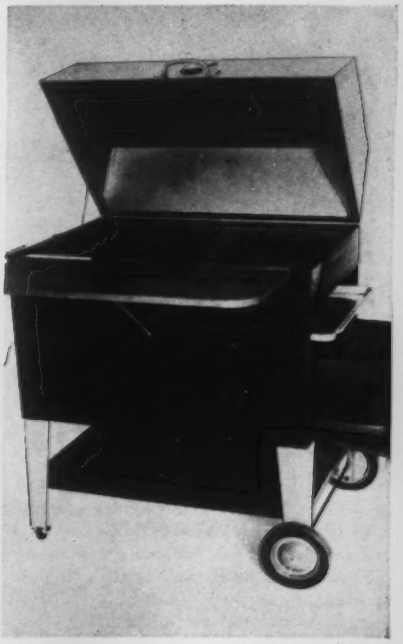
Electrodes commonly used in the past were of a wire brush type. These worked, but were far from ideal. They clogged easily when checking tar or asphalt surfaces, required frequent cleaning and replacement; lacked the flexibility necessary to conform to irregular surfaces; and could not be used on thin plastic covering without danger of puncturing the covering.





Tinker and Rasor eliminated these shortcomings by developing a new flexible electrode of electrically conductive Silastic molded on glass cloth. The *(Cont. Pg. 2)*





REDSTONES TO RED HOTS

Heat-stable silicone-based coatings are finding ever increasing use on products ranging from missiles to charcoal ranges. Among the leaders are "Sicon" finishes formulated with Dow Corning silicone resins by Midland Industrial Finishes, Waukegan, Illinois.

Unharmed by temperatures up to 1000 F, these silicone-based finishes provide long-lasting, positive protection against weathering, corrosion and chemical attack. Sicon finishes also retain excellent color, gloss and eye appeal even after extensive aging.

Sicon is applied to the nose cones of Redstone missiles, made by Chrysler Corporation, Missile Division, because this silicone coating possesses the thermal stability to withstand the heat surge generated under simulated re-entry conditions, whereas other finishes ignite and burn.

Colored silicone coatings are equally proficient in glamorizing and protecting hot kitchen and patio appliances. The popular charcoal ranges by Hasty Bake Manufacturing Company of Tulsa, Oklahoma, for example, are finished with an attractive Sicon coating that will withstand temperatures reaching 900 F. Under such extreme conditions, this silicone paint not only retains its color and gloss but is resistant to hot grease and weathering.

Other applications for silicone-based finishes: oil burners, mufflers, exhaust stacks, motorcycles, jet engines, boilers, housings, radio equipment, earth satellites, space heaters, home incinerators, radiators and other components and assemblies. What new application can you add to this list? Where can you use a silicone coating to provide protection and help maintain decorative appeal? *No. 241*

Waterproof Leather Boots

Upper leather treated with SYLFLEX®, the Dow Corning silicone for leather. Keeps water out. Lets leather breathe.

Waterproof rubber sole vulcanized to upper by unique process. Moisture cannot penetrate. Sealed seams guarantee dryness . . . More comfort, longer wear. Soft and flexible. For name of nearest dealer, circle . . . . *No. 242*

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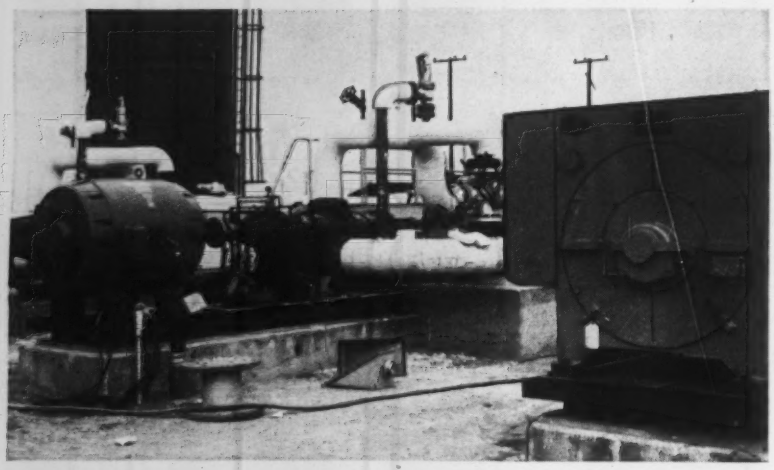

SAVE ON OUTDOOR MOTORS; SPECIFY SILICONE INSULATION

Dramatic proof of size and weight savings made possible by designing motors with silicone insulation systems is demonstrated by these outdoor direct coupled pump drives at the Alamitos Steam Station of Southern California Edison Company. Here, self-protecting silicone rubber insulation means substantial dollar savings in enclosure cost for the smaller, open frame motor.

Both of the new motors shown in the photo have 400-hp ratings. The difference in weight between the two motors is well over 1,000 pounds. Why is one motor so much larger than the other? Because the smaller Allis-Chalmers motor has a self-protected Silco-Flex insulation system incorporating Silastic®, the Dow Corning silicone rubber. The other motor is insulated with conventional materials.

Despite its much smaller size, the silicone insulated motor also has a 15% service factor not found in the larger unit. This extra cushion against overloads assures greater reliability and longer life for the smaller unit.

What's more, the self-protecting silicone rubber insulation system made possible a reduction in motor enclosure costs. Able to withstand all outdoor elements including flooding, the silicone insulated motor has an open, drip-proof frame. In contrast, the larger motor insulated with standard materials must be fully enclosed in a more costly weather-protected frame. *No. 243*

SILASTIC *(Continued)*

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The new electrode retains its shape and conductivity at temperatures ranging from —20 to 450 F — does not soften or become brittle — performs better, lasts longer. No wonder the manufacturer reports that electrodes of Silastic have received enthusiastic acceptance from industry.

The unique combination of properties that Silastic provides is the reason engineers look upon Silastic as an answer to a variety of design problems. *No. 244*

new literature and technical data on silicones

Selection Guide for Silicone Dielectrics reprinted from Electronics magazine provides a compact, comprehensive table of physical and electrical properties of silicone insulating materials. Cross tabulated, by uses and by physical forms, this handy reference table provides a convenient key to materials most suitable for different design problems. *No. 245*

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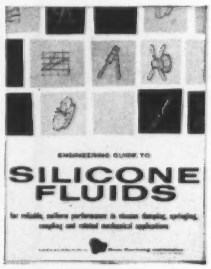

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Job-proved Dow Corning silicone lubricants readily meet severe performance requirements — help designers solve lubrication problems created by adverse operating conditions. Used on equipment ranging from freezers to core oven conveyors —at temperatures as low as minus 100 F, as high as 500 F. Send for a handy brochure on properties and applications of silicone lubricants. *No. 249*

Dow Corning Corporation, Dept. 7021, Midland, Michigan

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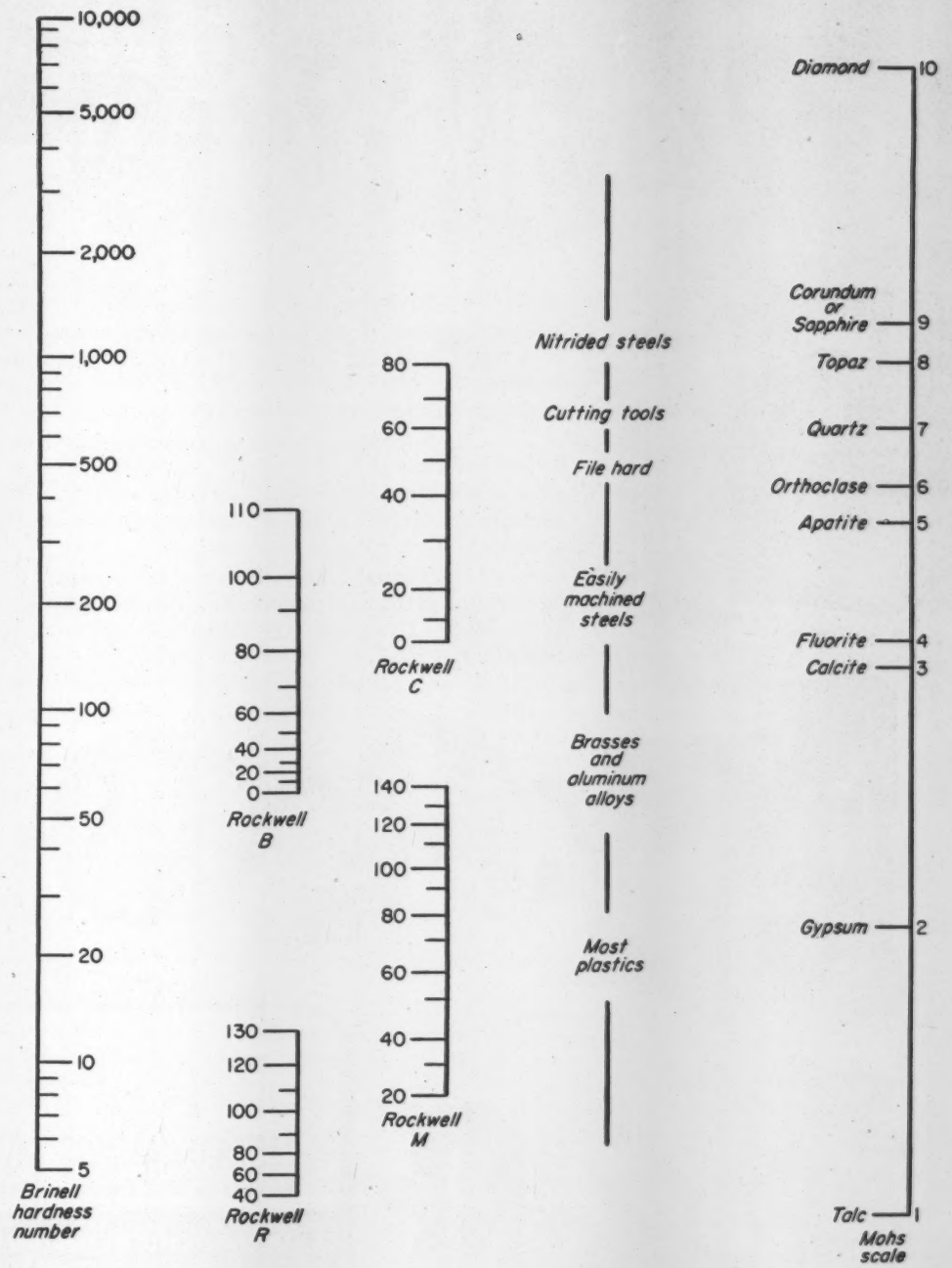
Approximate Comparison of Hardness Scales



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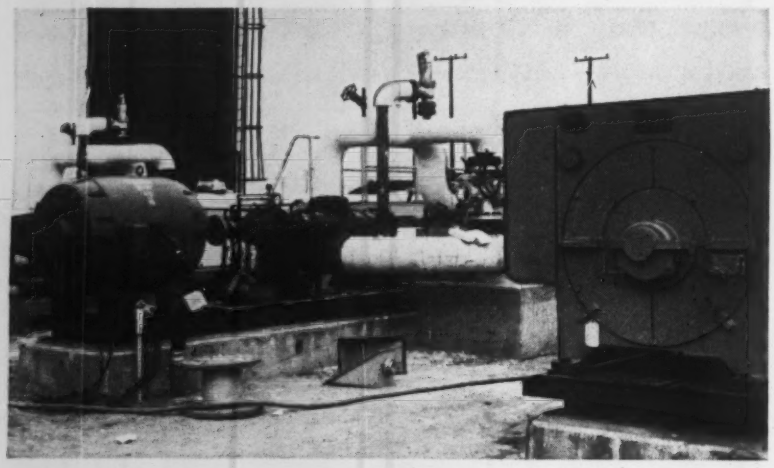

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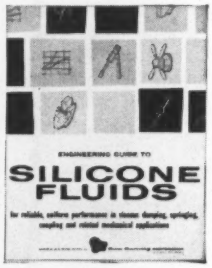

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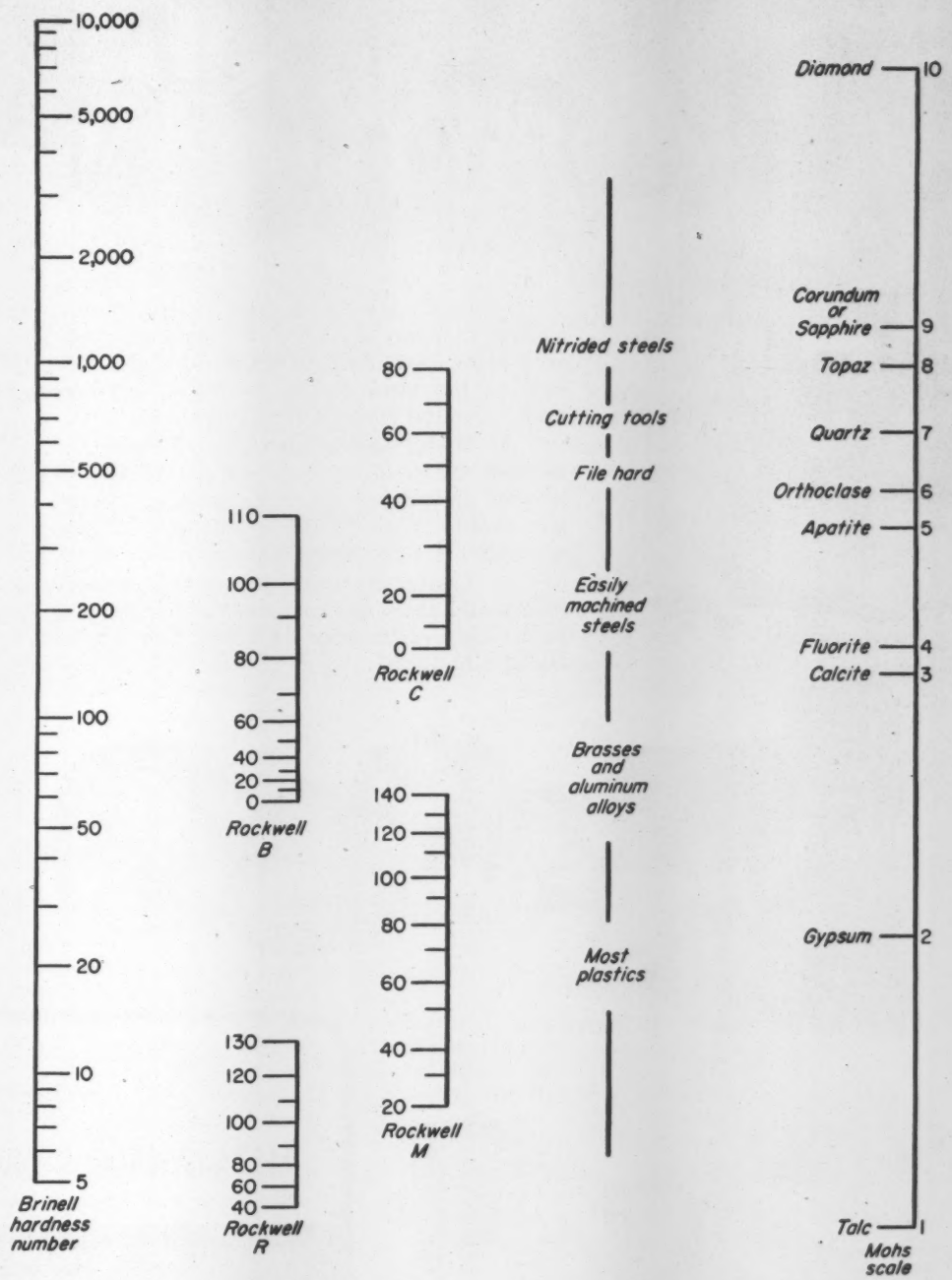

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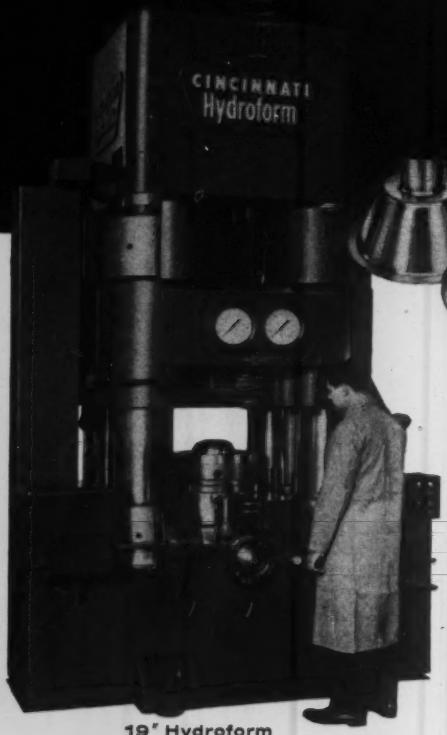
With three Cincinnati® Hydroforms, producing precision formed development parts is quick at kaupp

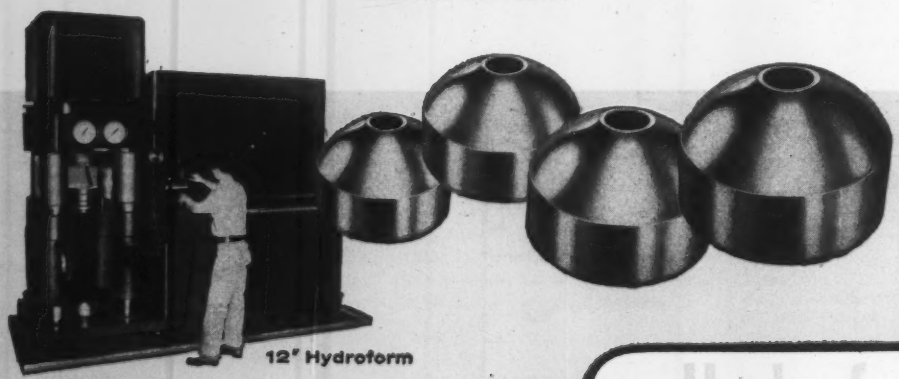


19″ Hydroform

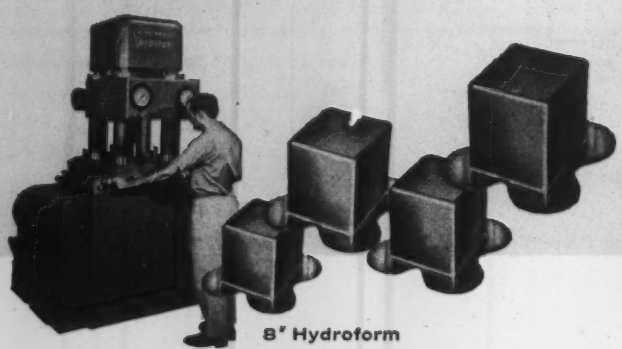
C. B. Kaupp & Sons, Maplewood, New Jersey, is a leading supplier of custom formed metal components, and has been since 1924. As a development shop, Kaupp found Hydroforming the ideal answer to faster, lower cost production of prototypes and pre-production drawn parts.

Hydroforming lowered tool costs . . . shortened time between release of drawings and the delivery of part samples . . . reduced the number of operations on most parts . . . and improved part quality. With 8″, 12″ and 19″ size Cincinnati Hydroforms in operation, Kaupp assures customers fast, economical service.

Look into the advantages of Hydroforming for producing your metal parts and components. For detailed information, call in a Meta - Dynamics Division field engineer, or write for Bulletin M-1908-1.



12″ Hydroform



8″ Hydroform

Hydroform

META-DYNAMICS DIVISION

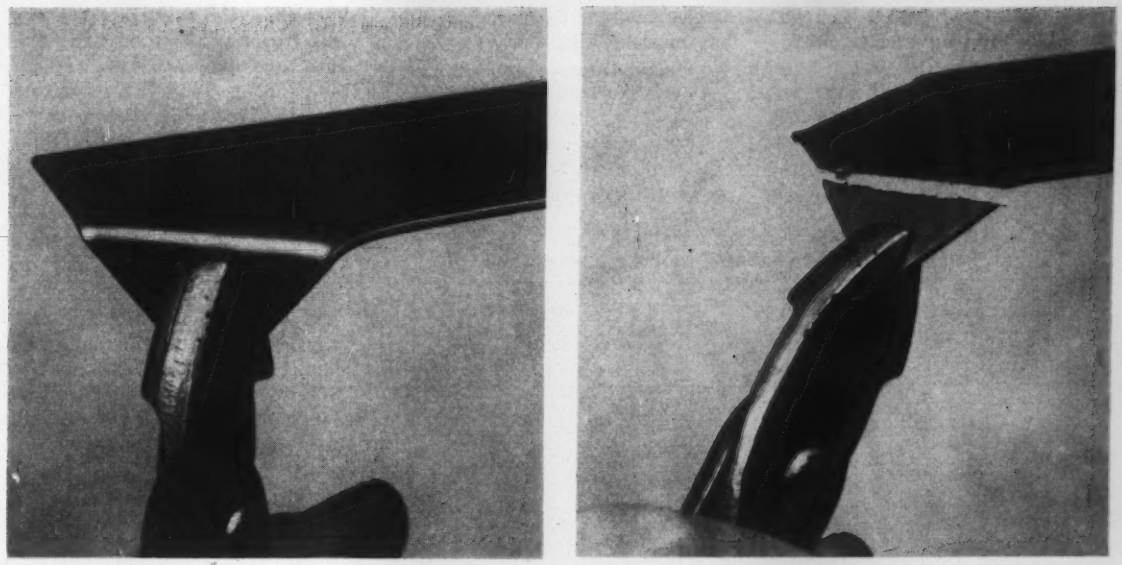
Machines for Metal Forming and Heat Treating

THE CINCINNATI MILLING MACHINE CO.

Cincinnati 9, Ohio, U.S.A.

CINCINNATI

Edited by
John A. Mock



Difference in ductility *between new sheet (left) and conventional sheet (right) is easy to see.*

Ductile Molybdenum Sheet Fabricated at Room Temperature

■ Ductile molybdenum sheet that can be bent double at room temperature without cracking is now commercially available from General Electric Co.'s Lamp Metals & Components Dept., Nela Park, Cleveland 12, Ohio. Ordinary sheet, in contrast, can be bent only about 20 deg under similar conditions.

Price of the new ductile sheet is the same as that of conventional molybdenum sheet, according to GE. Details as to how the sheet is made ductile have not been revealed.

Cup test comparison

Robert F. Johnson, general manager of the Lamp Metals & Components Dept. says the new type of sheet will literally "take the heat off molybdenum sheet metalworking." Formerly, temperatures as high as 1000 F were required for the manufacture of many formed molybdenum parts (see M/DE, Aug '57, p 112). Laboratory and field tests indicate the new sheet can be fabricated at room temperature. According to GE, it shows as much as five times the room temperature ductility of ordinary molybdenum sheet when tested by the Erichsen cup test method.

AVAILABLE SIZES OF NEW MOLYBDENUM SHEET

Thickness, in.	Width, in.
0.001 to 0.010	⅛ to 7
0.012 to 0.020	¼ to 7
0.025 to 0.030	½ to 7
0.035 to 0.375	½ to 10

Other advantages

Johnson also says the ductile

◀ For more information, circle No. 364

molybdenum sheet has far less tendency to delaminate on punching, stamping and shearing than do ordinary commercial grades of molybdenum.

The high ductility of the sheet should make it ideal for deep drawing operations. For example, it may be possible to form thick sections of sheet by Hydroforming techniques in which heat cannot usually be tolerated.

Seven Silicone Rubbers Are Easy to Process

Included is a new fluoro-silicone

■ One of silicone rubber's biggest drawbacks, poor processability, has apparently been overcome by Dow Corning Corp., Midland, Mich. The company recently introduced seven new silicone rubber compounds that are characterized by "good processability."

The seven materials are: 1) a fuel and solvent resistant fluoro-silicone rubber, 2) a fluoro-silicone rubber masterbatch, 3) two silicone rubber wire and cable compounds, 4) two general purpose compounds, and 5) a silicone rubber masterbatch.

PROPERTIES OF EASY-TO-PROCESS SILICONE RUBBERS

Type →	LS-63U[a]	LS-422[b]	52[c]	82[c]	1601[d]	1602[d]	433[e]
Specific Gravity	1.46	1.44	1.15	1.24	1.35	1.21	1.09
Shelf Life, mo	3	—	3	3	3	3	6
ORIGINAL MECHANICAL PROPERTIES							
Ten Str, psi	1000	950	900	850	740	1000	650
Elong, %	130	150	270	200	450	450	300
Tear Str, psi	60	100	60	85	65	110	50
Compr Set (22 hr at 300 F), %	23	30	22	25	—	—	23
Hardness (Shore A)	67	70	55	85	53	63	41
Brittle Point, F	−90	−90	−100	−100	−100	−100	—
AFTER AGING IN ASTM NO. 1 OIL[f]							
Ten Str Chg, %	−3	—	—	—	—	—	—
Volume Chg, %	+1	—	+7	+6	—	—	—
Hardness Chg, pts	−1	—	−9	−5	—	—	—
AFTER AGING IN ASTM NO. 3 OIL[f]							
Ten Str Chg, %	−30	—	—	—	—	—	—
Volume Chg, %	+5	+4	+44	+35	—	—	—
Hardness Chg, pts	−2	−6	−28	−25	—	—	—
AFTER AGING IN JP-4 FUEL[g]							
Ten Str Chg, %	−25	—	—	—	—	—	—
Volume Chg, %	+10	—	—	—	—	—	—
Hardness Chg, pts	−6	—	—	—	—	—	—
ELECTRICAL PROPERTIES							
Dielec Str, v/mil	350	—	500	500	500	500	—
Dielec Const (60 cps)	6.2	—	2.9	2.9	3.1	3.0	—
Dissip Factor (60 cps)	0.04	—	0.002	0.0005	0.004	0.002	—
Vol Res, ohm-cm	1×10^{13}	—	0.7×10^{14}	0.5×10^{14}	1.0×10^{14}	0.2×10^{14}	—

[a]Press cured 5 min at 240 F, then oven cured 8 hr at 392 F.
[b]Sample containing 20 parts Hi Sil 303 press cured 5 min at 240 F, then oven cured 24 hr at 300 F.
[c]Press cured 5 min at 240 F, then oven cured 24 hr at 480 F.
[d]Press cured 5 min at 240 F. Tensile and elongation tests performed on 1/32-in. wall of Silastic 1601 and 1602 extruded over No. 18 stranded wire.
[e]Press cured 5 min at 240 F, then oven cured 24 hr at 480 F.
[f]Aged 70 hr at 300 F.
[g]Aged 70 hr at room temperature.

1. Fluoro-silicone rubber

Dow Corning's new fluoro-silicone rubber, identified as Silastic LS-63U, is easy to mold, extrude and calender. The compound can also be dispersed in solvents and applied as a coating.

Silastic LS-63U is the newest addition to the company's line of fluoro-silicone rubbers. The first was Silastic LS-53 introduced in 1956 (see *Materials & Methods*, Nov '56, p 163). The company recently reduced the price of Silastic LS-53 to $16 per lb. Silastic LS-63U is also priced at $16 per lb.

According to the developer, Silastic LS-63U is serviceable at both extremely high and extremely low temperatures. It has very low volume swell and little physical property change when immersed in jet fuels and hydraulic oils. The fluoro-silicone compound is suitable for seals and gaskets used in missiles and aircraft.

2. Fluoro-silicone masterbatch

The fluoro-silicone rubber masterbatch, called LS-422, is composed of a fluoro-silicone polymer with reinforcing silica filler added. Because the masterbatch readily accepts additional fillers, compounds up to 80 durometer (Shore A hardness) can be formulated.

3. Two cable compounds

Silastic 1601 has been designed to meet the requirements of wire and cable insulation for Underwriters Laboratories standards for 200 C rated fixture and appliance wire. According to the developer, Silastic 1601 maintains its electrical properties at high temperatures and remains flexible over a wide temperature range. The compound requires no mill freshening prior to extrusion.

Silastic 1602 is recommended for cable constructions outlined in Mil-W-8777, Mil-C-19381 and Mil-W-16878 specifications. The compound is said to release readily

from mill rolls without the use of scraper blades.

4. Two general purpose compounds

Silastic 52 and Silastic 82 are 50 and 80 durometer general purpose compounds that can be blended to obtain any intermediate hardness. Outstanding benefit of the new materials is ease of processing. The stocks release from mill rolls without the use of scraper blades. They are also easy to extrude. The cured compounds remain flexible after several days exposure at 600 F, according to the developer. Both compounds will probably be suitable for gaskets, seals, diaphragms and tubing used in aircraft, automobiles and appliances.

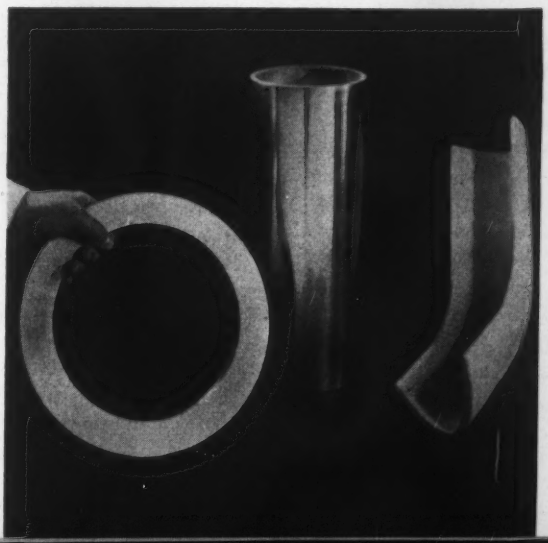
5. Silicone rubber masterbatch

Silastic 433 silicone rubber masterbatch is a silicone polymer with reinforcing silica added. The material can be formulated into compounds up to 80 durometer. Stocks compounded from the new material are said to process easily and are said to release readily from mill rolls.

Stripping *silicone rubber compound from a mill without a scraper blade.*

Cable compound *can be extruded without mill freshening.*

***Porous nickel shapes** include (from left to right): polished burner ring 12 in. in dia; highly polished contactless roller 20 in. long; and unpolished chute.*



Porous Nickel Shapes Are Large, Intricate

■ Large, intricate porous nickel shapes are being produced by Corning Glass Works, Corning, N. Y.

Called Cormet A and produced by an improved powder metallurgy process, the nickel material is being fabricated into sheets 12 by 30 in. and cylinders 12 in. in dia and 2 ft long. Thus far, no details have been revealed as to how the process works; however, Corning says that the large sizes are made possible by a "new hydrostatic pressing process."

According to Corning:

1. Cormet A can be made into unusual shapes not possible by conventional pressing. For example, holes, projections and indentations can be produced without

additional finishing.

2. The process provides more uniform porosity, with pore diameters controlled between 1 and 45 μ. Depending on porosity, yield strengths as high as 10,000 psi are possible.

3. Although maximum thickness of presently available parts is 1 in. thicker sections are possible.

4. Surfaces can be machined to a high polish with no adverse effects on permeability.

Corning says it entered the powder metallurgy business in searching for a way of eliminating marks and wrinkles on glass parts caused by chutes used to carry molten glass from the furnace to the mold. The answer was a noncontacting chute made of Cermet A: the glass now rides on a thin cushion of air forced through the pores of the chute. Thus far, the material is being used primarily for similar conveyors used to process highly sensitive materials such as camera and x-ray film, gelatinized paper, adhesive materials, plastics, and other products that have high surface sensitivity at elevated temperatures.

Two Duplex Electroplates Now Extend Corrosion Life

■ Two duplex plating systems have emerged from the developmental stage and are now being used commercially to protect and decorate automotive and appliance parts. Both techniques are said to greatly improve the corrosion resistance of electroplated parts.

One plating system is a duplex chromium technique developed by Metal & Thermit Corp., 1700 E. Nine Mile Rd., Ferndale, Detroit 20. The other system is a duplex nickel process developed by Brown-Lipe-Chapin, Div. of General Motors Corp., Syracuse, N. Y.

Duplex chromium

The duplex chromium system is a modification of the conventional copper-nickel-chromium system in which a thicker-than-normal chromium plate (0.000025 in.) is deposited crack-free and pore-free. The plating technique applies two different types of bright chromium plate. The first features good throwing power and plates in hard-to-reach recesses; the second builds up the total thickness of the chromium electroplate.

According to H. D. McLeese, Metal & Thermit vice president, "Accelerated laboratory tests demonstrate this new process can add years to the life of chromium-plated automobile trim in areas where the atmosphere is considered highly corrosive."

In addition to work done by Metal & Thermit Corp., independent studies at Battelle Memorial Institute show that die castings plated by the duplex chromium process have a two to three-fold increase in corrosion resistance over conventionally plated die castings (see M/DE, Feb '59, p 162).

Accelerated corrosion studies (Corrodkote and copper-accelerated acetic acid salt spray tests) conducted by E. J. Seyb, Jr. and others at the Electrochemical Research Laboratory of Metal & Thermit show that duplex chromium-plated automobile trim has about 500% better corrosion resistance than conventionally plated trim.

Corrodkote test: In the Corrodkote test a standard, highly corrosive slurry is applied to a specimen in the form of a coating. After the coating dries, the specimen is placed in a noncondensing humidity cabinet for 16 hr; then the specimen is cleaned and corrosion evaluated. Corrodkote tests on conventional chromium-plated automotive trim were stopped after one 16-hr cycle, whereas six complete 16-hr cycles had to be run on duplex chromium-plated parts to reach the same degree of failure.

Copper-accelerated test: The copper-accelerated acetic acid salt spray test is an extension of the more familiar acetic acid salt spray test in which copper chloride

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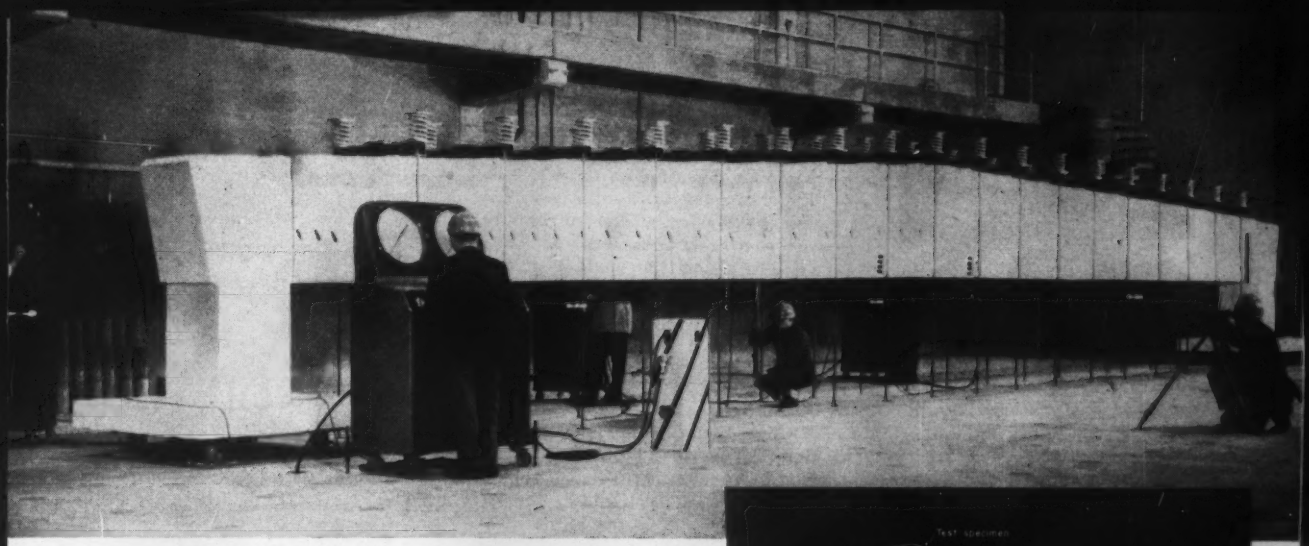
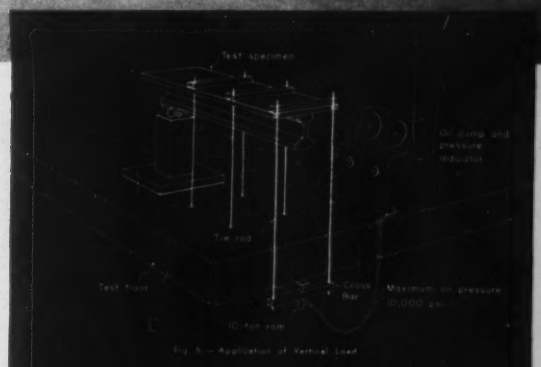
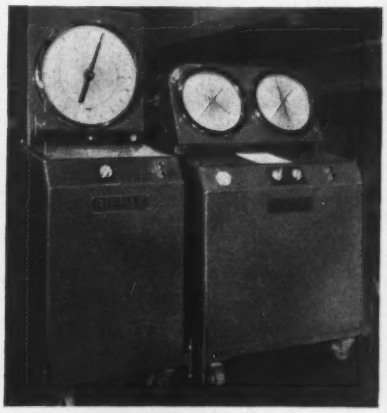


This laboratory is a giant testing machine in itself

Designed to accommodate a wide range of concrete specimens, from small beams to large structural assemblies, this hydraulic testing machine utilizes the building floor as an integral part. 690 holes in the floor permit versatile arrangements of tie rods which connect load applicator bars to a series of 10-ton rams below floor level.



Custom designed concrete testing machine at Portland Cement Association's Research and Development Laboratories, Skokie, Illinois. Diagram shows hydraulic mechanics.



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is added to the test solution. A higher temperature is also used. Rate of attack is thereby speeded up from four to six times. A rear door sash panel plated with ordinary chromium ran for 16 hr in the copper-accelerated acetic acid salt spray test before failure. With duplex chromium the part ran 128 hr without failure.

According to Seyb, finely cracked chromium deposited on top of crack-free chromium results in a very low rate of corrosion, or none at all. Low corrosion results because the many fine cracks on the surface of the duplex chromium plate dispersed electrolytic cell action over a large area. As a result, current density is less than required for anodic perforation of the underlying metals.

Duplex nickel

Brown-Lipe-Chapin's plating technique, called Dura-Plate, is a duplex deposit of nickel—one layer colum-

Inflatable metal tubing

Wolverine Tube Div., Calumet & Hecla, Inc., 17200 Southfield Rd., Allen Park, Mich. has announced that it will soon start experimental production of light-walled seamless metal tubing that can be shipped in ribbon form and inflated at the point of use.

In some sizes, the tubing can be inflated by using tap water pressure as shown in the photo above.

The inflatable tubing, to be known as Strubing, is said to offer two major cost advantages: 1) low shipping costs since only the tube "walls" are shipped and not the "holes," and 2) low production costs since the process (technically classified as cold rolling) can economically produce thin-walled tubing of materials in thicknesses that are either unavailable today or are available only at high costs.

Typical uses for small-diameter inflatable tubing might include: instrument lines, automotive tubing (as for radiator, overflow and thermostatic control lines), and tubes for ball-point pens or mechanical lead pencils. Strubing made of special metals such as stainless steel, zirconium, titanium, tantalum or columbium might be used in the manufacture of light-walled, large diameter, seamless rocket and missile bodies. The inflatable tubing might also be used to line chemical piping and vessels. This would be done by inserting the tubing in a pipe or tank and inflating it to form an inner liner.

The methods and equipment used for inflating Strubing will probably vary with the application of the material and its dimensions. The company's engineers have used hydraulic pressure, air pressure and mechanical means to inflate the tubing.

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The Cooper-Bessemer Corp., Mt. Vernon, Ohio and Grove City, Pa.
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Dayton Casting Co., Dayton, Ohio
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Bulletin 32— Meehanite Quality Control Assures Uniform Dependability.

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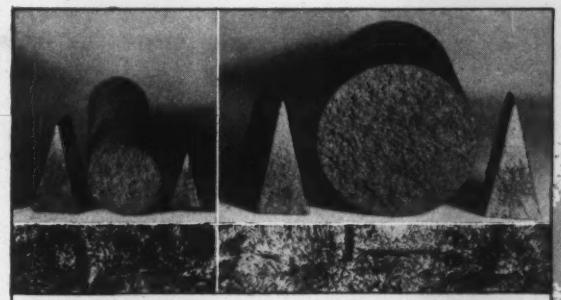
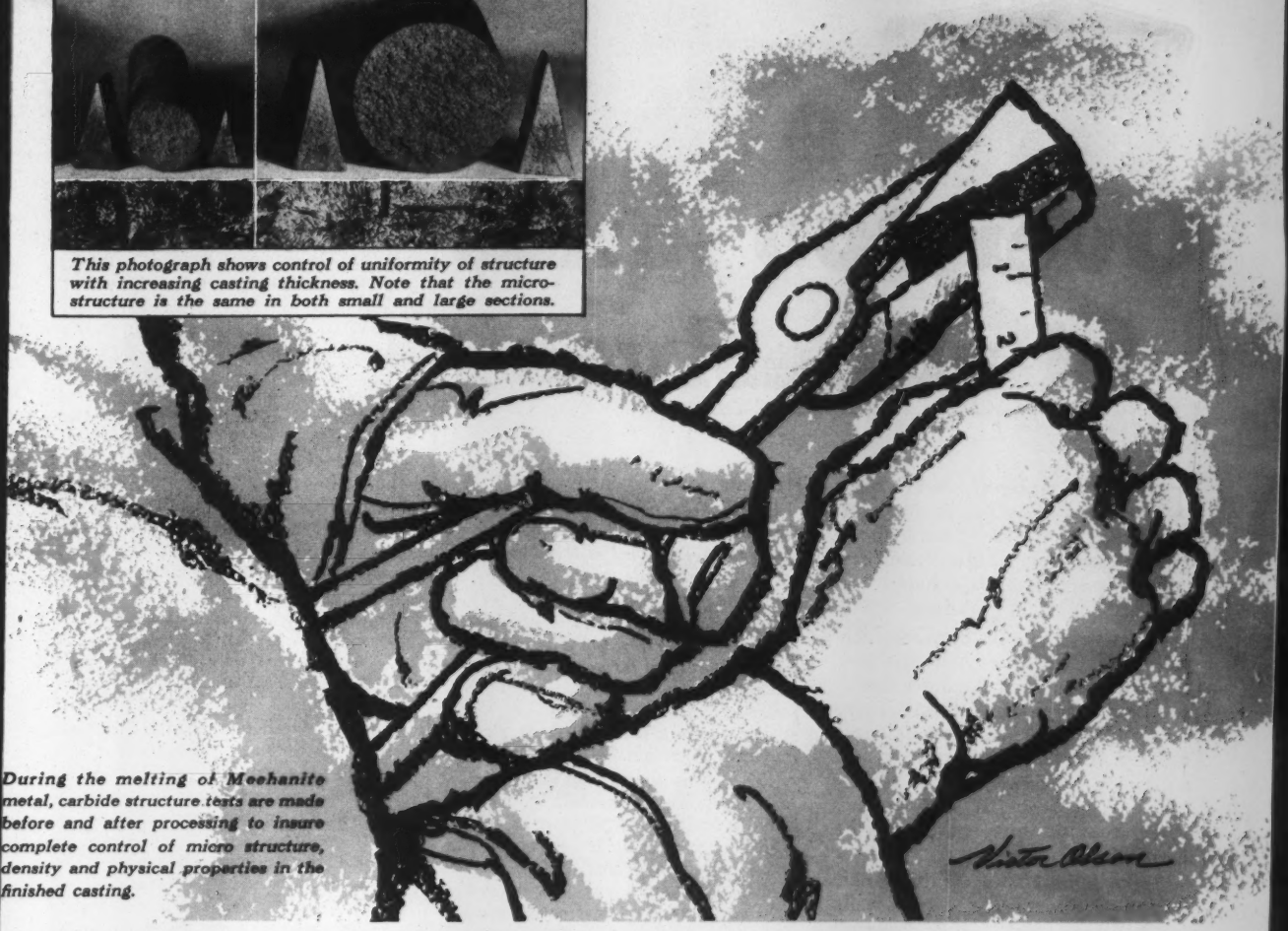


This photograph shows control of uniformity of structure with increasing casting thickness. Note that the micro-structure is the same in both small and large sections.



During the melting of Meehanite metal, carbide structure tests are made before and after processing to insure complete control of micro structure, density and physical properties in the finished casting.

Casting solidity and uniform properties are assured regardless of dimensions with Meehanite metal.

By the aid of a patented discovery, Meehanite® has established a means of controlling structure and mechanical properties of castings of all designs and sizes. This unique procedure is of vital significance to engineering production both in obtaining dependable castings with uniform physical properties as well as in assuring lowest costs in processing for use.

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Adhesives made by B.F.Goodrich will bond almost any materials you can name—joining them to themselves or each other. Sometimes, adhesive bonding is the only practical method of fastening. In other cases, adhesives often have special advantages—high strength, less weight, lower cost or greater freedom of design.

Brake linings, supersonic planes, helicopter rotor blades, curtain walls for buildings, for example, have all proven to be stronger, safer when bonded together with B.F.Goodrich adhesives. High-strength adhesives took the place of 500,000 rivets in the B-58 supersonic bomber (picture).

Each month, perhaps a dozen new formulations join the ranks of our adhesives as we work with industry to find ways to improve product design and production techniques. Here are some recent examples:

B.F.Goodrich has perfected an adhesive that permits vinyl-coated sheet steel to be deep-drawn—stretched as much as 35 per cent without weakening the bond or damaging the coating.

Two new adhesives have been developed by B.F.Goodrich for bonding polystyrene foam. One is ideal for use with foamed-in place polystyrene. The other is recommended for bonding pre-foamed polystyrene shapes to themselves or to steel, aluminum, formica and other materials.

For bonding some materials that in the past stubbornly refused to stick together, B.F.Goodrich has a new group of rubber-like adhesives. Synthetic films, such as nylon, polyethylene and cellophane can now be bonded to all kinds of metal as well as to paper, wood, glass, foils and plastics.

With so many stock adhesives to choose from, and so many other special ones possible, it may be a problem to find the best one. You can get more information by writing to B.F.Goodrich.

When you write, give details. It's surprising how often small details help us recommend the one adhesive that does the job.

How will you apply the adhesive? Spray, roller coat, extrusion or brush? What materials are to be joined? Can heat and pressure be used? Any temperature limitations? Method of assembly (present or proposed)? Is metal used? If so, how is the metal pretreated?

How strong must the bond be? Must it have heat resistance? How much? Chemical resistance? Are there any requirements for taste, odor, toxicity, color? Any other requirements?

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What's new IN MATERIALS

nar and one layer laminar—followed by a heavy layer (five times normal thickness) of crack-free chromium.

The process is presently being used in the company's Syracuse, N. Y. and Elyria, Ohio plants in the manufacture of plated zinc die castings and stamped steel automotive and appliance parts. The company does not intend to license the process.

According to W. H. Safranek, H. R. Miller and C. L. Faust, of Battelle Memorial Institute, who have conducted independent research on duplex nickel electroplates under the sponsorship of the American Zinc Institute, ". . . duplex nickel electroplates should extend the corrosion-free life of plated die castings to at least one year in highly corrosive areas."

Research at Brown-Lipe-Chapin shows that duplex nickel-plated parts endured accelerated corrosion tests with good performance and remained bright and durable through most rigorous outdoor atmospheres in all seasons of the year.

In plating a duplex deposit of nickel, the first layer is plated from a solution which is sulfur-free, a feature that is said to prevent corrosion penetration at the grain boundaries. This first layer is columnar, retarding vertical penetration of a corrosive media. The second layer of the plating sequence is a bright nickel deposit, laminar in structure, that provides a lustrous finish.

Glass-Alkyd Compound for Military Uses

A glass-alkyd molding compound for military applications has been introduced by Glaskyd Inc., 232 Eckel Rd., Perrysburg, Ohio. The compound, called Glaskyd 2051, is classified as an MAI-30 material covered by Mil-M-21699.

The molding material is supplied in continuous rope form in diameters from ½ to 1¼ in. It is also supplied in "logs" or precut pieces when larger diameters are required.

The compound is said to have good dimensional stability, high arc resistance, good moisture resistance and good dielectric properties. It is readily molded by compression, transfer and plunger methods. Po-

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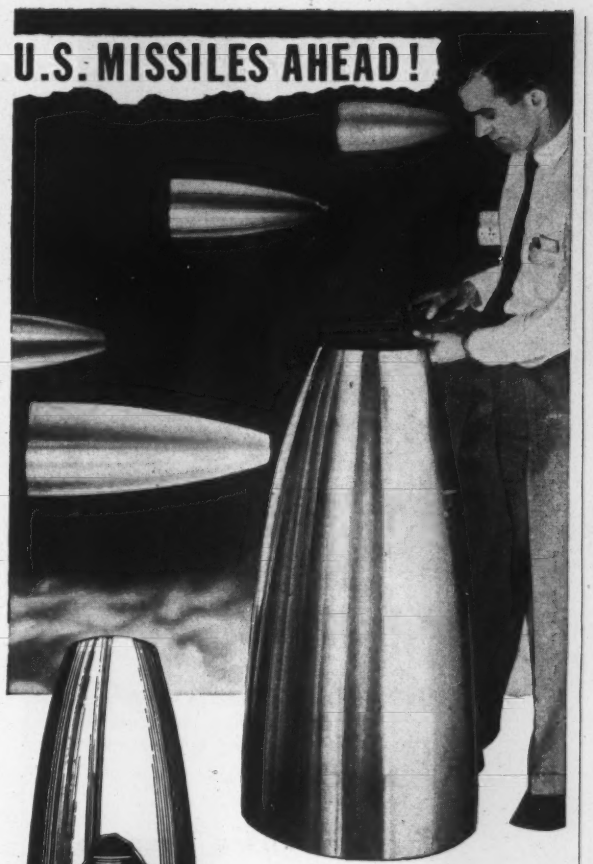

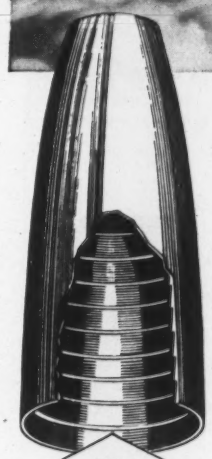

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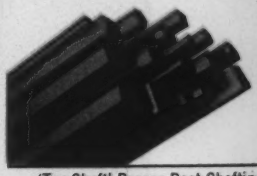

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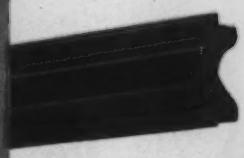

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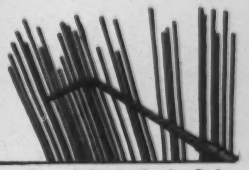

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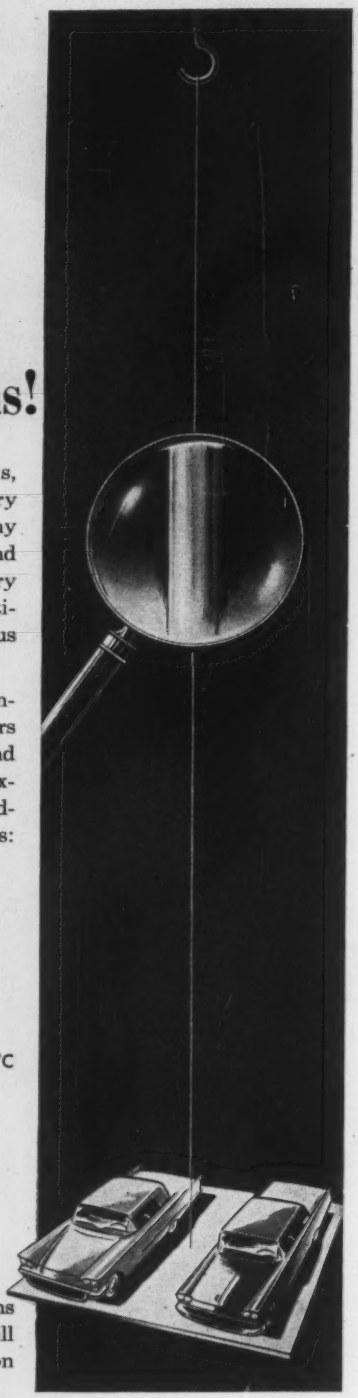

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Mallory 1000 is used for gaining new compactness and strength in gyroscope rotors and other rotating inertial members and in many types of counterbalances. It is exceptionally effective as a radio-active shielding material. Here are its specifications:

Density	16.96 grams/cc
Ultimate tensile strength	112,000 psi.
Mod. of Rupture (simple beam)	220,000 psi.
Elongation (% in 2")	2.5% Minimum
Hardness Rockwell "C"	24-30
Mod. of Elasticity	40,000,000 psi.
Coef. of Expansion (25-500°C)	5.4×10^{-6} in./in./°C
Elec. Conductivity	14.0% IACS
Elastic Limit (tension)	25,000 psi.
Yield Strength (0.2% offset)	75,000 psi.
Torsion Modulus (modulus of rigidity)	19,200,000 psi.
Angle of Twist at Rupture	166°
Shear Strength	81,100 psi.

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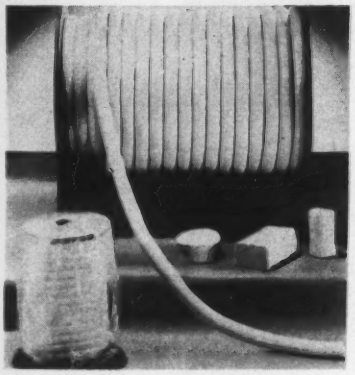


Continuous rope *and precut pieces of glass-alkyd molding compound.*

tential uses include circuit breakers, switch housings, terminal boards, connectors, fuse holders and rotary switches.

Low Firing Enamels Get More Attention

Low firing enamels, though not new, are still getting a great deal of attention in the porcelain enamel industry. Probably one of the most important advantages of enamels that can be fired at low temperatures is that they reduce the danger of metal warpage.

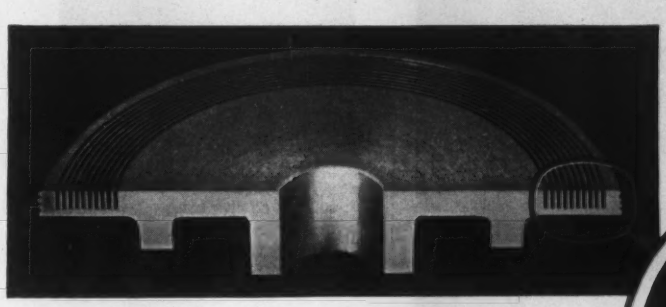
A report given at the 1958 Shop Practice Forum of the Porcelain Enamel Institute, Inc., held recently at the University of Illinois, pointed out some possible areas of application for these low firing enamels. This report, together with another interesting report on the electrical properties of conventional porcelain enamels, is summarized below.

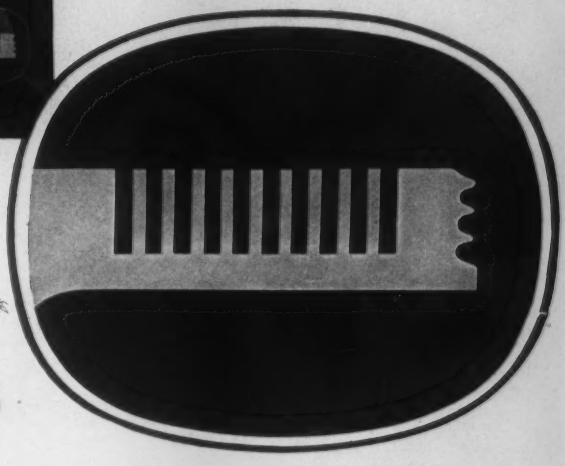
1. Low temperature enamels

The properties and uses of porcelain enamels designed for firing at 1400 F were discussed by H. R. Spiers of Pemco Corp. Spiers says that low warpage (0.02 to 0.04 in.) should permit the use of cold rolled steel or lighter gage enameling iron in the production of some enameled parts. In some cases, it might be pos-

Proceedings of the Forum may be obtained from the Porcelain Enamel Institute, Inc., Associations Bldg., 1145 19th St., N. W., Washington 6, D. C. at a price of $10.

Do Your Castings Require Sharp Corners Like These?





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Permits the Machining of Precise Corners

The fine dispersion of graphite in Eaton Permanent Mold Iron and its dense, non-porous, homogeneous structure make it an ideal material for many difficult machining operations where accurate dimensional results and sharp corners are essential.

Because its superior structure permits the machining of extremely thin sections and has the ability to take a high surface finish, Eaton Permanent Mold Iron is recommended for such critical applications as bearing retainers, connecting rods, pulleys, carburetor bodies, valve bodies, and service valves.

If you have applications which require these exceptional characteristics, our engineers will be happy to work with you.

The part shown above required that 10 grooves, .023" wide and .125" deep, leaving 9 lands .015" wide, be rapidly and simultaneously machined. Eaton Permanent Mold Iron proved to be the ideal material—completely eliminating the problem of curling chips in the small grooves, and crumbling of lands during machining.

Check these Important Advantages:

- ★ **Dense, non-porous, homogeneous structure**
- ★ **Freedom from inclusions**
- ★ **Excellent tensile strength**
- ★ **Ability to take a high surface finish**
- ★ **Freedom from leakage under pressure**
- ★ **Intricately cored sections**
- ★ **Uniformity of castings**
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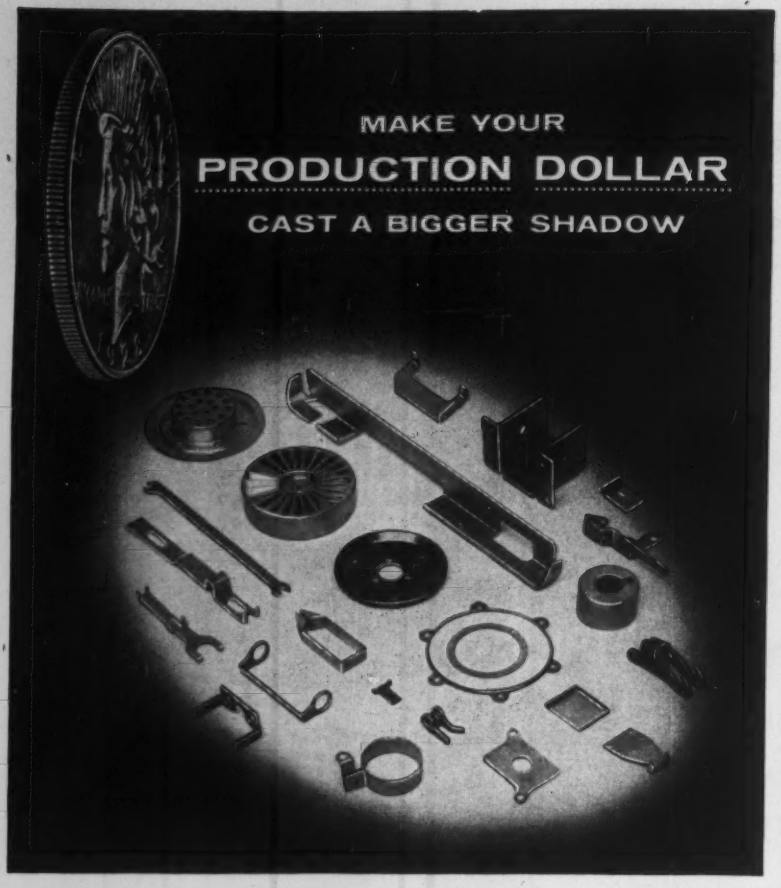

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7352 Atoll Ave., No. Hollywood, Calif.

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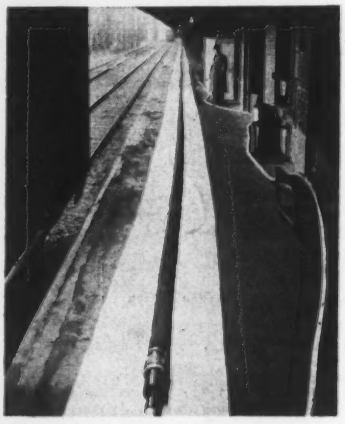
sible to use a lighter gage cold rolled steel in place of a heavier gage enameling iron. Low warpage should also reduce chipping on the assembly line and in shipping.

Applications where it is practical to fire both ground coat and cover coat at 1400 F include flatware for ranges, refrigerator liners, light reflectors and architectural panels. The 1400 F enamels require a nickel deposit to insure good adhesion. Applications where 1400 F enamels are not practical include sanitary ware, hot water tanks and signs.

Spiers explained that in the development of 1400 F enamels, care has been taken to maintain as nearly as possible the same good working properties normally associated with higher firing enamels. Ground coats have good dipping and draining qualities, good burnoff and copperhead resistance, and adequate firing range. (Copperhead: reddish-brown defects in sheet iron ground coats which con-



Long, unspliced rubber hose—Shown here is a 500-ft length of unspliced, 4-in. i.d. rubber hose made by a new, continuous production process. Up to this time, no hose with an i.d. greater than 1½ in. has been produced in unspliced lengths over 100 ft, it is claimed. The continuous production process, details of which have not been revealed, is said to resemble the process used in making automobile tires. The long-length, large-bore rubber hose is available from Goodyear Tire & Rubber Co., 1144 E. Market St., Akron 16, Ohio.

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exceptionally close limits...

The photograph shows the connecting rod of an unusual hydraulic pump built by a company whose name is known everywhere.

The finish in the bore of both the large hole and the small hole must be held to very fine profilometer reading.

In addition, the axes of these two holes must be parallel to each other within exceptionally close limits. Naturally, the user of a cast bronze part such as this turns to Bunting in order to assure strictest adherence to his print and specifications.

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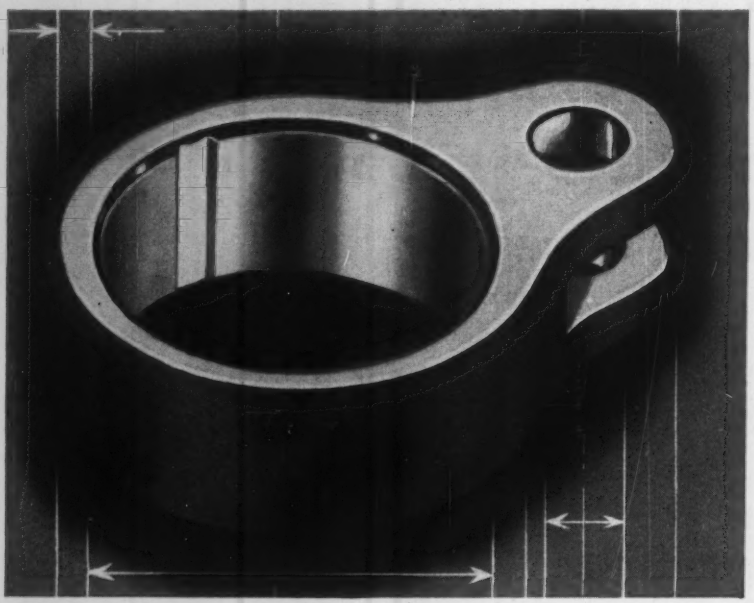

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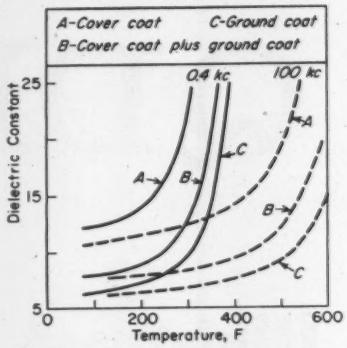


***Fig 1**—Dielectric constant vs temperature for three porcelain enamels.*

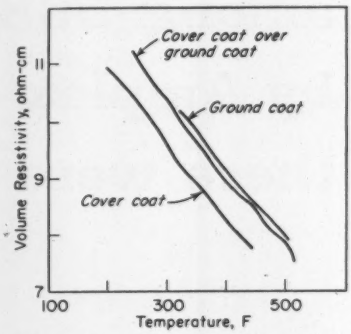


***Fig 2**—Volume resistivity vs temperature for three porcelain enamels.*

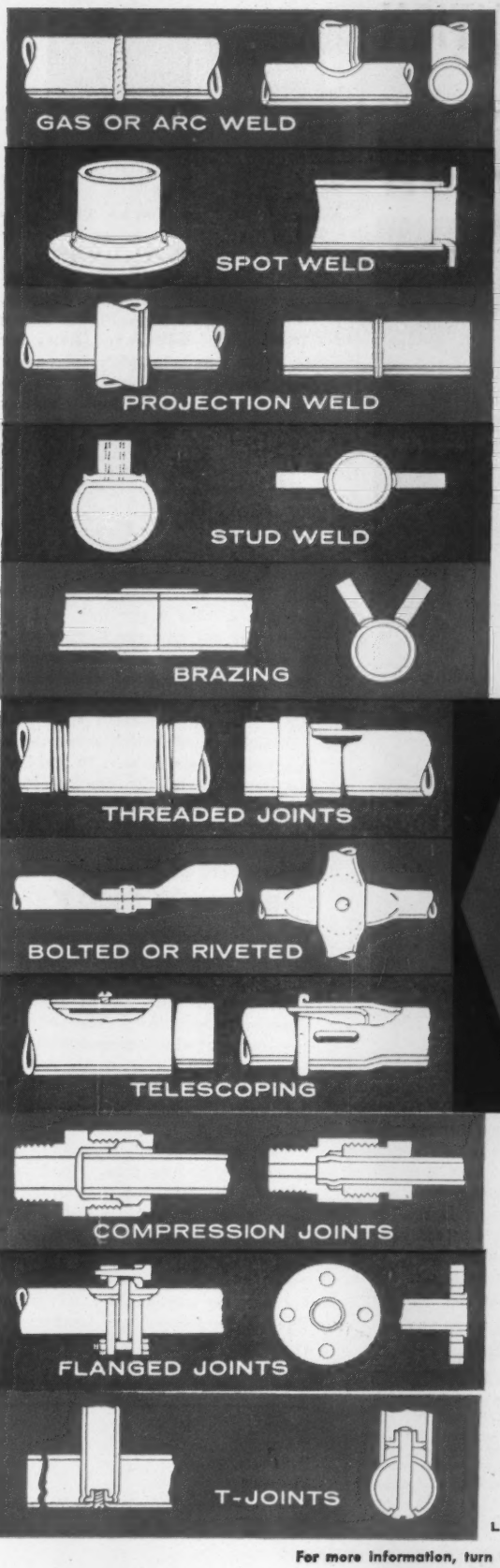
tain a base layer of oxidized iron and which destroy the continuity of the enamel.)

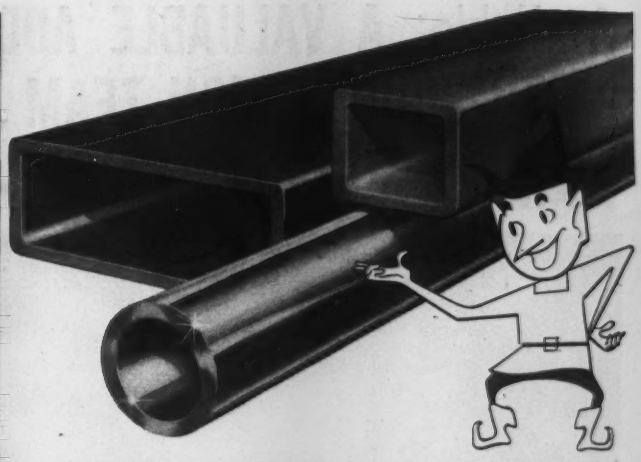
The cover or top coats of 1400 F enamels have good color stability, good acid resistance, good aging qualities and good hairline resistance. (Hairline: fine line defects produced by the ground coat showing through the top coat.)

2. Electrical properties of enamels

C. G. Bergeron of the University of Illinois presented data on the room and elevated temperature electrical properties of three porcelain enamels. The data show that porcelain enamels offer definite advantages over some organic insulations as electrical insulations in the higher temperature ranges.

Dielectric constant—The change in dielectric constant with increasing temperature is shown in Fig 1. The three enamels were tested at two fre-





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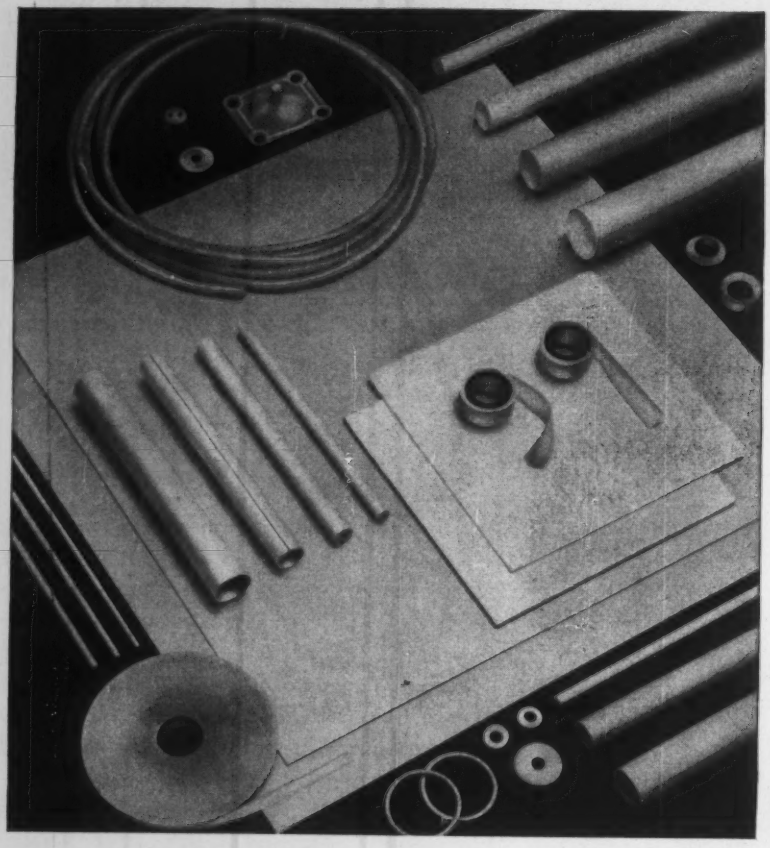

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quencies, 0.4 and 100 kc. The dielectric constant at the lower frequency increased rapidly as temperature increased; the change with temperature was less at the higher frequency.

Volume resistivity—Fig 2 shows the change in volume resistivity for the three enamels with increasing temperature. The slopes of the respective curves are approximately equal; however, the values for the ground coat were greater than the values for the cover coat. The combination cover coat over ground coat had volume resistivity values almost the same as those of the ground coat alone.

Dielectric strength—The ground coat had an average dielectric strength of 345 v per mil, and the cover coat 485, at room temperature. In each measurement the weakest point in the area of the coating under the electrode failed first; thus any minute imperfection such as a pinhole or an oxide-rich area may be responsible for a failure. In addition, the thickness of the coating influences the dielectric strength values.

Alloy Steel Resists Softening at 1000 F

An air hardening alloy steel has been developed for use in jet aircraft and other structures requiring high strength and ductility at low and elevated temperatures. The principal advantage of the new material over conventional high strength steels is its ability to resist softening upon continued exposure to temperatures up to 1000 F.

The alloy, called Dynaflex, was developed by Latrobe Steel Co., Latrobe, Pa. It is supplied in billets, bars, forgings and special shapes.

The steel can be air hardened to full hardness even in large section sizes; as a result, residual hardening stresses are greatly minimized. The high tempering temperature permitted with Dynaflex is said to

COMPOSITION OF DYNAFLEX (%)

Carbon	0.40
Silicon	0.90
Manganese	0.30
Chromium	5.00
Molybdenum	1.30
Vanadium	0.50

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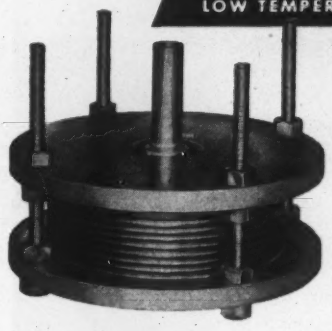
LOW TEMPERATURE SILVER BRAZING ALLOY



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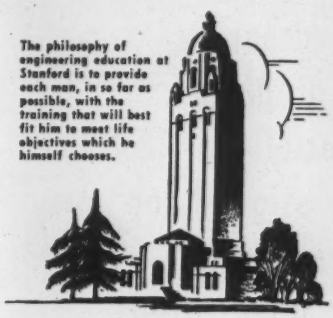
The philosophy of engineering education at Stanford is to provide each man, in so far as possible, with the training that will best fit him to meet life objectives which he himself chooses.

This vacuum bellows is part of the liquid target assembly located on the business end of the linear accelerator developed by Stanford University. The bellows is .0106" brass, joined to half-inch-thick Muntz metal flanges. This is a difficult brazing job at best—being done successfully at Stanford University, using Silvaloy 45. Heating is by torch and carbon block. Needless to say, despite the technical difficulties of this job, only a perfect, strong vacuum-tight joint is acceptable.

For this reason, technicians at Stanford University use Silvaloy 45 and Deoxo Flux for their reliable quality and consistent performance.

Silvaloy brazing alloys and fluxes are helping to speed production, lower costs and improve brazing results in many fields. Call your nearest Silvaloy distributor for information or technical assistance.

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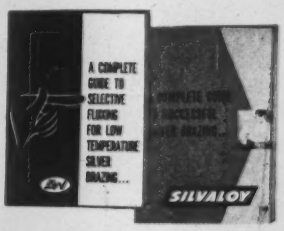

Two complete reference manuals for low-temperature silver brazing and fluxing are available upon request. Send for either one or both. ★ ★ ★ ★ ★ ★ ★

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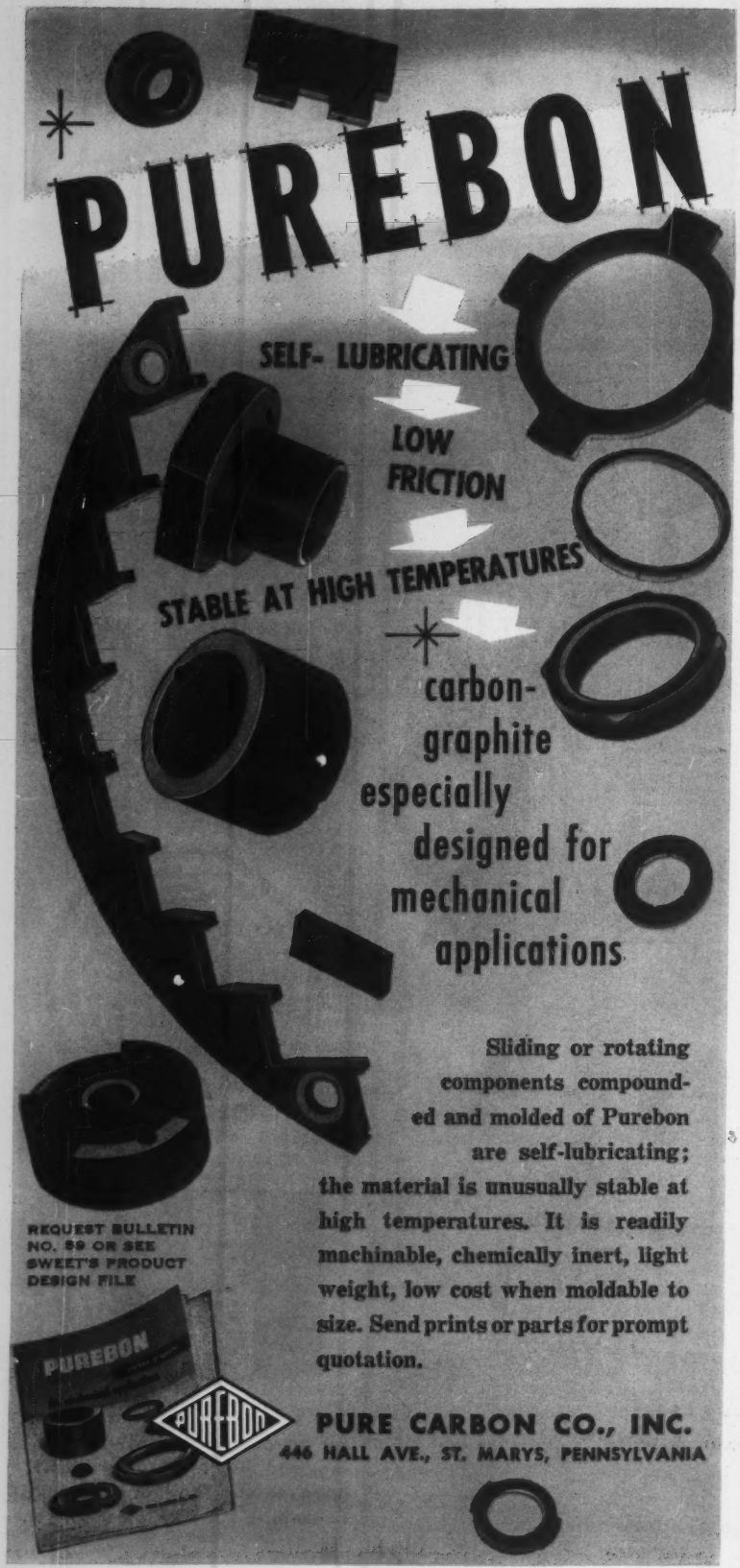
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PROPERTIES OF DYNAFLEX

PHYSICAL PROPERTIES	
Specific Gravity	7.80
Density, lb/cu in.	0.282
Ther Cond (80 F), Btu/hr/sq ft/°F/ft	10.2
Coef of Ther Exp, per °F	
80-200 F	6.0
80-400 F	6.4
80-800 F	7.0
80-1200 F	7.3
MECHANICAL PROPERTIES[a]	
Tensile Strength, psi	
Room Temperature	265,000
500 F	230,000
1000 F	180,000
Elongation (in 2 in.), %	
Room Temperature	9
500 F	10
1000 F	11
Yield Strength, psi	
Room Temperature	225,000
500 F	195,000
1000 F	140,000
Reduction of Area, %	
Room Temperature	32
500 F	35
1000 F	35

[a]Tests conducted on longitudinal specimens heat treated to Rockwell C50 at 1825 F, air cooled, tempered at 1000-1100 F.

allow the nearly complete relief of residual hardening stresses necessary for maximum toughness at high strength.

Other important advantages claimed for the alloy steel include exceptional ease of forming and working, good weldability, relatively low coefficient of thermal expansion, better than average corrosion and oxidation resistance, and low strategic alloy content.

Heat treatment

Hardening: According to the producer, Dynaflex should be preheated slowly to 1200-1400 F, then heated to 1825-1875 F. A controlled atmosphere should be used to prevent decarburization and scaling. Parts are air cooled from the hardening temperature.

Tempering: Dynaflex is usually

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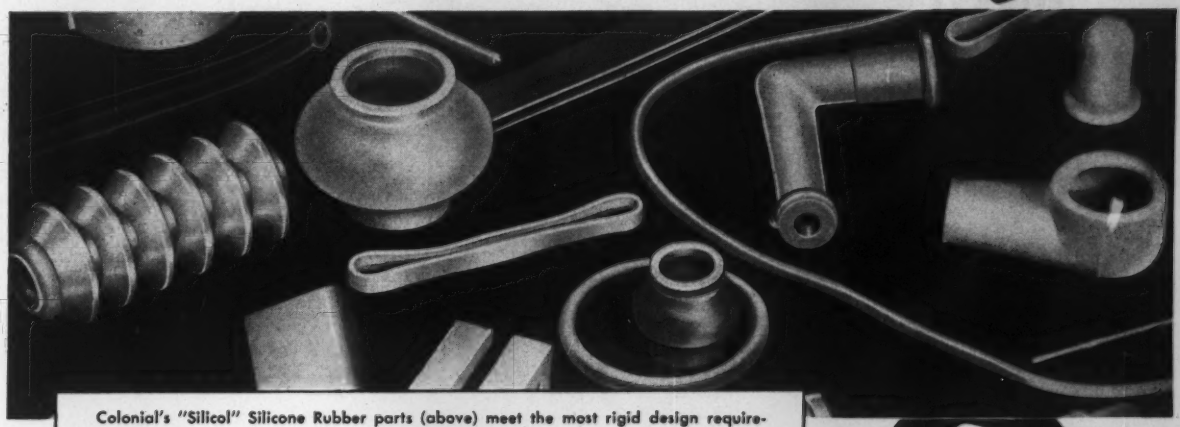

Colonial's "Silicol" Silicone Rubber parts (above) meet the most rigid design requirements. Having the same shrinkage as organic rubber, existing molds can be used with "Silicol" where desired. Typical parts and end products we produce regularly from natural and synthetic rubber are shown at right.

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tempered in the 1000 to 1100 F range for 2 hr or longer depending on the size of the section and the application. Double tempering is recommended.

Polycarbonate Coating Bonds to Most Metals

A solution coating of Lexan polycarbonate resin can be applied by conventional methods to iron, stainless steel, aluminum, copper and zinc. It serves as both a decorative and a protective coating. Tests show the solution coating has fair adhesion to nickel and poor adhesion to tin-coated steel.

Data released by General Electric Co., Chemical Materials Dept., Chemical & Metallurgical Div., 1 Plastics Ave., Pittsfield, Mass. indicate that polycarbonate-coated parts have to be heated for several minutes at 500 to 530 F to fuse the resin to the part.

The resin is soluable in certain chlorinated hydrocarbons, dioxane, tetrahydrofuran, dimethylformamide and phenols. According to GE, solids content is limited to 25%.

Lexan polycarbonate resin was developed by GE two years ago (see M/DE, June '57, p 158).

TFE Tape Lubricates, Seals Pipe Fittings

A chemically inert TFE tape that seals and permanently lubricates pipe fittings has been announced by Minnesota Mining & Mfg. Co., 900 Bush Ave., St. Paul 6, Minn. Because the tape has good anti-sticking characteristics, joined pipe can

***Applying** TFE tape to pipe.*

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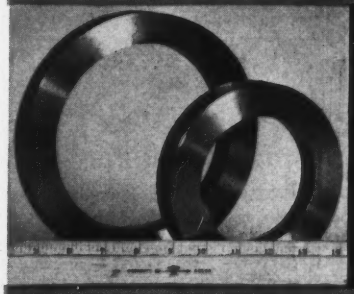
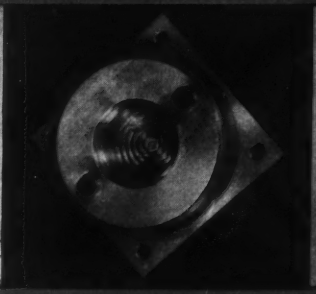


Scatter Rings Used in Radiation Research



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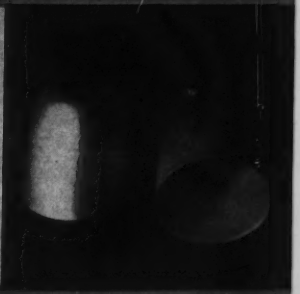

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What's new IN MATERIALS

be easily loosened and detached years after the threads are taped.

The unfused film tape, called "Scotch" brand No. 547, can be applied to pipe fittings in seconds. It conforms to all types of pipe threads and fittings.

The tape is said to withstand processing temperatures from the liquid oxygen range through that of superheated steam. It is not affected by oil traces or other lubricants in a steam line.

The tape is available in 36-yd rolls in ¼ to 8-in. widths.

Curing Aid Improves Butyl's Heat Resistance

More heat resistant butyl rubber parts are made possible by a new curing process developed by United States Rubber Co., 1230 Avenue of the Americas, New York 20. The curing process uses phenol dialochol resin as the curing agent for butyl instead of sulfur.

The resin-cured butyl is said to withstand a sustained temperature of 400 F, compared to 300 F for standard butyl, 270 F for SBR rubber, and 250 F for natural rubber (NR). According to the developer, resin-cured butyl withstands temperatures higher than 700 F for short periods of time.

Potential uses for phenol dialochol resin-cured butyl rubber include tire curing bags, steam hose, conveyor belts for moving hot materials, motor mountings, gaskets and belts for hot machinery, seals, press pads and hydraulic press diaphragms. Tests show tire curing bags made of resin-cured butyl rubber last five times longer than standard butyl bags.

Conductive Alloy Strong at 750 F

A relatively new copper-base alloy combines high electrical conductivity with good strength retention at high temperatures. Tensile strength is 70,000 psi at room temperature and 51,600 psi at 750 F.

The alloy, called Amzirc, consists of high conductivity, oxygen-free OFHC copper and a small amount of

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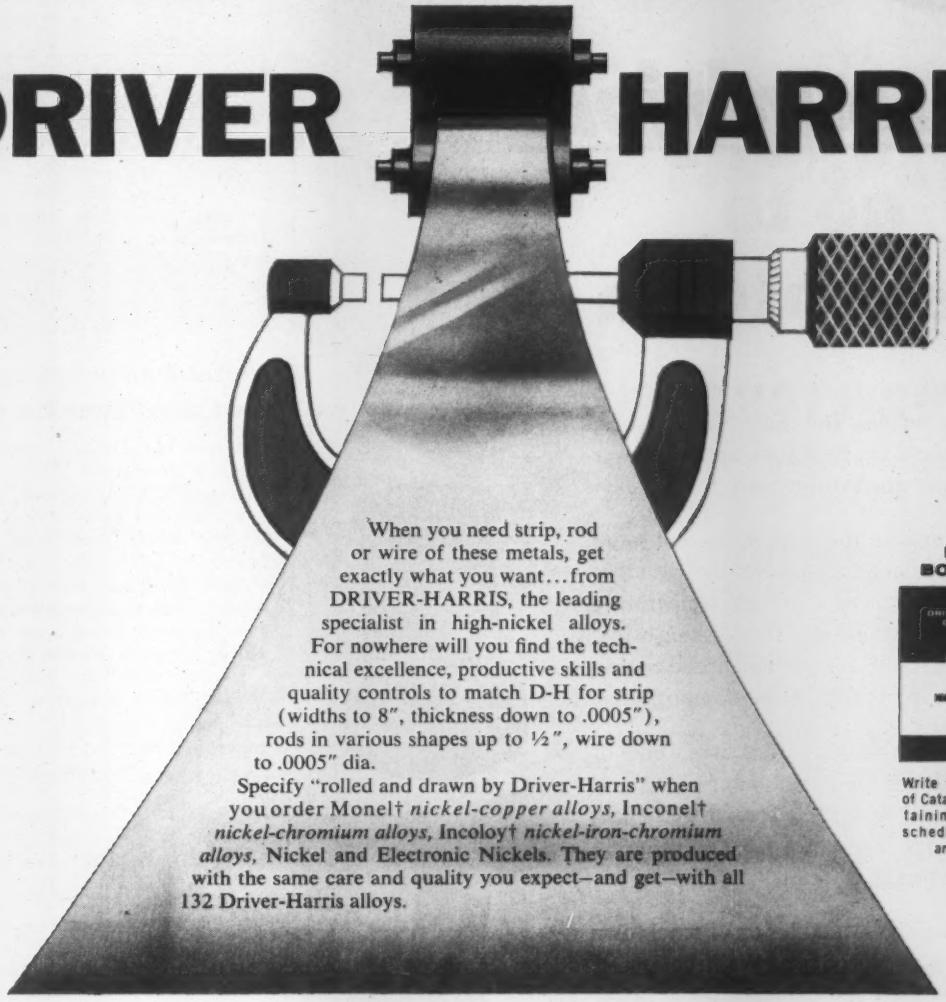
DRIVER HARRIS



When you need strip, rod or wire of these metals, get exactly what you want... from DRIVER-HARRIS, the leading specialist in high-nickel alloys. For nowhere will you find the technical excellence, productive skills and quality controls to match D-H for strip (widths to 8", thickness down to .0005"), rods in various shapes up to ½", wire down to .0005" dia.

Specify "rolled and drawn by Driver-Harris" when you order Monel† *nickel-copper alloys,* Inconel† *nickel-chromium alloys,* Incoloy† *nickel-iron-chromium alloys,* Nickel and Electronic Nickels. They are produced with the same care and quality you expect—and get—with all 132 Driver-Harris alloys.

FREE BOOKLET

Write for your copy of Catalog N-59 containing complete schedule of sizes and prices.

T.M. REG. U.S. PAT. OFF. †T.M. THE INTERNATIONAL NICKEL COMPANY, INC. PRODUCTS OF HUNTINGTON ALLOY PRODUCTS DIVISION.

DRIVER-HARRIS* COMPANY

HARRISON, NEW JERSEY • BRANCHES: Chicago, Detroit, Cleveland, Louisville

Distributor: ANGUS-CAMPBELL, INC., Los Angeles, San Francisco • In Canada: The B. GREENING WIRE COMPANY, Ltd., Hamilton, Ontario

MAKERS OF THE MOST COMPLETE LINE OF ALLOYS FOR THE ELECTRICAL, ELECTRONIC, AND HEAT-TREATING INDUSTRIES

SPECIAL PURPOSE ALLOYS SINCE 1893 — TRADE MARK REG. U.S. PAT. OFF.

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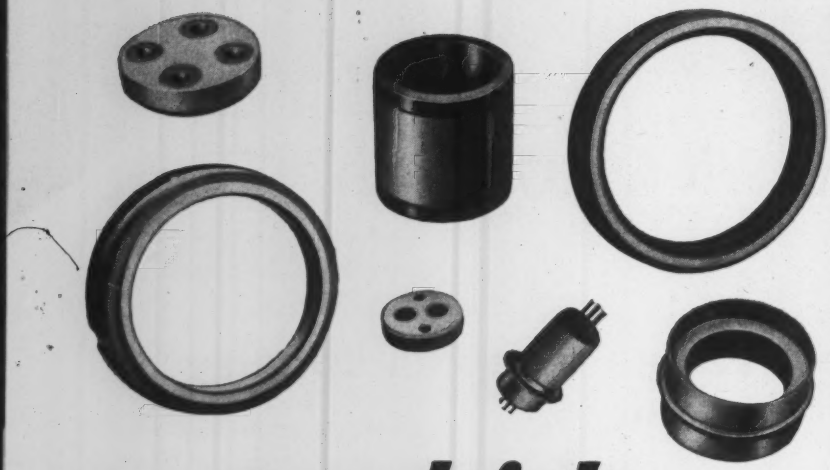


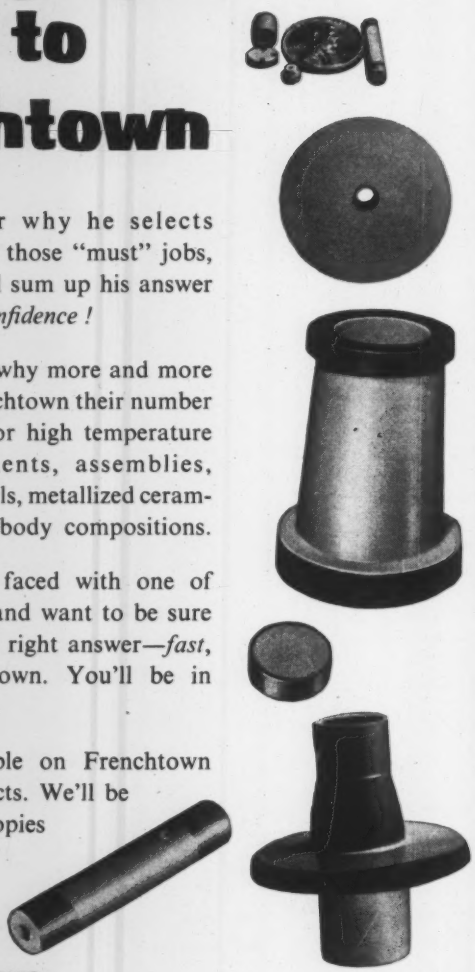
the *tough jobs* go to Frenchtown

Ask any engineer why he selects Frenchtown *first* for those "must" jobs, and chances are he'll sum up his answer in a single word—*confidence !*

It's the reason, too, why more and more engineers make Frenchtown their number one supply source for high temperature ceramics, components, assemblies, ceramics-to-metal seals, metallized ceramics, and specialized body compositions.

Next time you are faced with one of those "tough jobs" and want to be sure to come up with the right answer—*fast*, check with Frenchtown. You'll be in good company.

Literature is available on Frenchtown materials and products. We'll be happy to send you copies without obligation. Write *today*.



frenchtown PORCELAIN COMPANY

FRENCHTOWN, NEW JERSEY

For more information, turn to Reader Service card, circle No. 406

What's new IN MATERIALS

PROPERTIES OF AMZIRC*

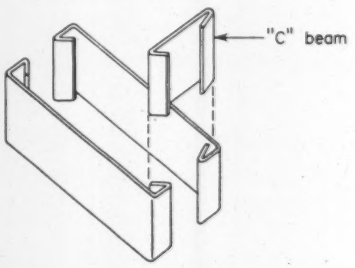
Tensile Strength, psi	
Room Temperature	72,000
750 F	51,600
900 F	39,400
Yield Strength, psi	62,000
Elongation (in 2 in.), %	
Room Temperature	12
750 F	15
900 F	19
Electrical Conductivity, % IACS	90-95

*Specimen cold worked 85%, aged 1 hr at 700 F.

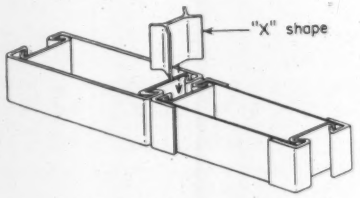
high purity zirconium. It was developed by American Metal Climax, Inc., 61 Broadway, New York 6. Potential uses include rectifier bases, rotor wedges, studs for x-ray tubes, electronic tube side rods, resistance welding wheels and tips, and fine wire.

Metal Panel System for Large Structures

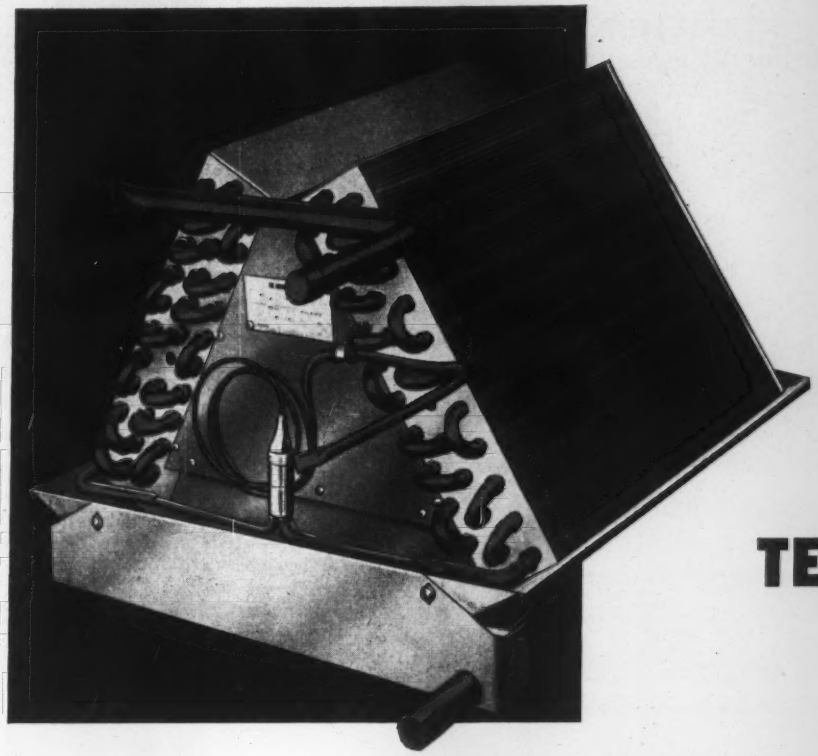
A new metal panel system may simplify construction of truck bodies and other large structures. The system, conceived by Paul Kratzmaier, Neoteric International Ltd., Nassau, Bahamas, BWI, requires no nails, screws, welding or riveting in fabrication. Panel faces with crimped-over edges are joined by a "C" beam which, when pushed into place, holds



***'C' beam** joins panel faces.*



***'X' shape** joins basic panels.*



How to TEMPER *the* TEMPERATURE

MATHES relies on WOLVERINE TUBEMANSHIP

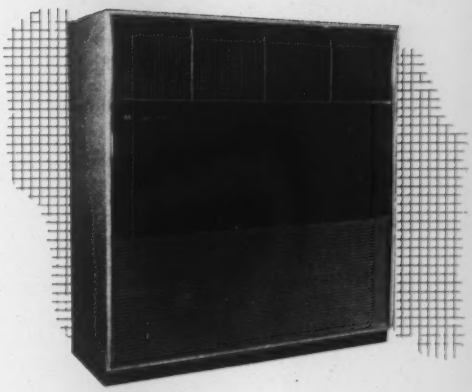
Wolverine supplies the Mathes Company Division of Glen Alden Corporation, Fort Worth, Texas, with three Tubemanship-made products: Precision-drawn Wolverine Capilator®, used for metering; commercial copper tube for hook-ups, condenser and evaporator coils and other fabrications; and aluminum extruded shapes for trim.

Mathes takes great pride in their research and development program for summer/winter air conditioning systems. Along with strict quality control, flexibility is their keynote. Simply by selecting from various Mathes components, an architect or contractor can install almost any size job regardless of tonnage requirements.

Incidentally, Mathes backs up their quality story with a written five-year warranty covering condenser and evaporator coils as well as condensers.

Yes, Wolverine contributes to Mathes products just as they do for the many, many others which make up industry's blue book. If you use copper, brass or aluminum tube and shapes, check into the Wolverine story.

Write for the TUBEMANSHIP BOOK—today!



See Wolverine Tube at Booth 519 — 11th Exposition of the Air Conditioning and Refrigeration Industry—November 2 through 5, Atlantic City, New Jersey.

CALUMET & HECLA, INC.
CALUMET DIVISION
URANIUM DIVISION
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EXPORT DEPARTMENT, 13 EAST 40TH STREET, NEW YORK 16, NEW YORK

For more information, turn to Reader Service card, circle No. 444

No. 5 of a Series

GRIPPING STORIES
from the files of Angier Adhesives

The Case of the COSTLY CONTACT

Acme had a problem. Their new line of sandwich panels was so popular they couldn't make them fast enough. So they turned to automation. The honeycomb cores were conveyed past automatic adhesive spray guns – through drying lamps and on to "Assembly" where the faces were contact-bonded to the body of the panel.

Then Acme discovered another problem. Their adhesive was being deposited unevenly and they were getting surprisingly poor mileage from their new installation.

Acme called in an Angier man. He showed them how a specially-formulated Angier contact cement would spray smoothly and uniformly, even at maximum line speeds, and with no heavy edges or excessive overspray.

In addition to a full line of contact cements and other adhesives, Angier offers unequalled application know-how. This vast fund of practical knowledge has been gained by the service engineers of Interchemical's Finishes Division in their daily experience with some of the largest industrial lacquer and enamel users. For *real* economy in adhesives, call in an Angier man *first.*

Call or write today for more information on Angier's line of Contact Cements.

ANGIER ADHESIVES

INTERCHEMICAL CORPORATION
Finishes Division
120 Potter St., Cambridge 42, Mass.
Midwestern Plant: HUNTINGTON, IND.

For more information, turn to Reader Service card, circle No. 472

edges so that faces cannot move in or out.

Key shape in the panel system is a simple rolled "X" shape. This shape, when inserted between abutting panels, holds their edges together and grasps the "C" beam and the panel edges.

Leaded Steel Tubing Is Easy to Machine

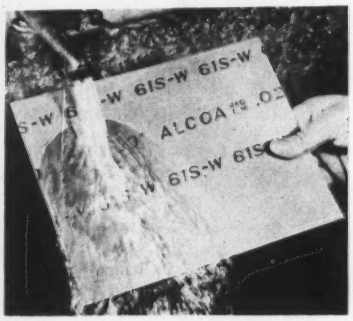
Leaded C-1020 carbon steel tubing, said to have outstanding machining properties, is offered by Superior Tube Co., 1548 Germantown Ave., Norristown Pa. The addition of 0.15 to 0.35% lead to the C-1020 analyses increases machinability from 72 to 85-90% and surface cutting speeds from 120 to 140-150 fpm.

According to the developer, there is virtually no difference in physical and mechanical properties between leaded and nonleaded C-1020 carbon steel. The leaded grade is recommended for most screw machine operations.

The leaded steel tubing can be heat treated, machined and forged under normal conditions without hazard from the lead content. The tubing is furnished in seamless form in sizes from 0.012 to 1⅛-in. o.d.

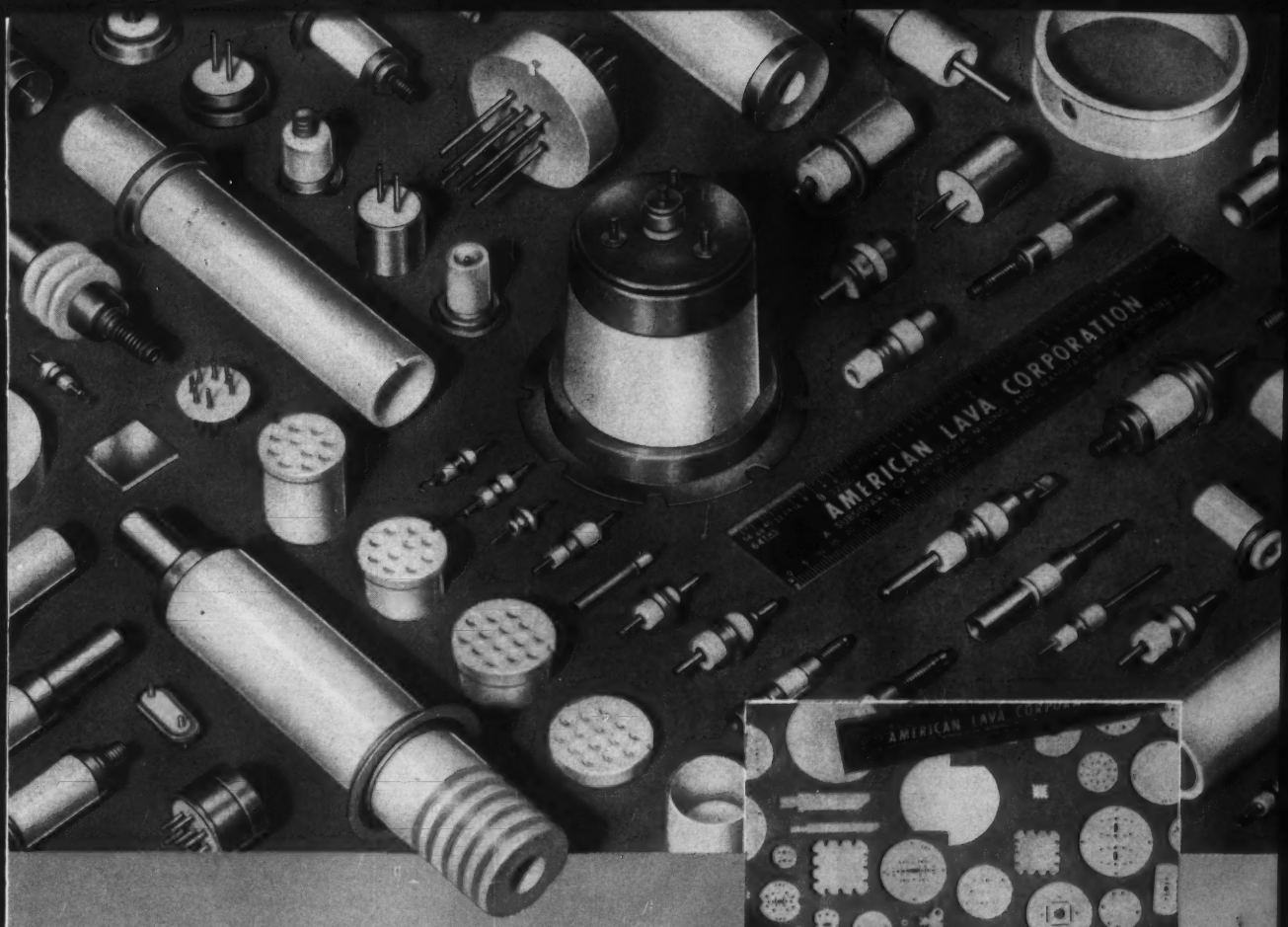
Removable Coating for Metal, Glass Surfaces

A hard, scratch resistant transparent coating provides temporary protection to polished metals, glass and plastics during fabrication and



***Removing** inorganic coating from aluminum panel with warm water.*

For more information, circle No. 522 ➤



AlSiMag pioneered micro-miniature ceramics . . . some as thin as 0.005". Relatively high strength, superior performance at high temperatures, high frequencies. Excellent record for withstanding fatigue, heat, shock, vibration.

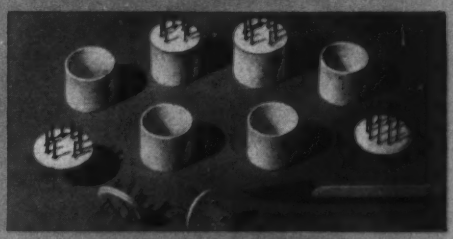
RELIABILITY

IS AN OUTSTANDING CHARACTERISTIC OF

AlSiMag® CERAMICS

AlSiMag Ceramics offer exceptional resistance to heat and erosion. They have marked electrical and physical stability at elevated temperatures and in varying environments. Chemically inert. Good strength. Can be accurately fabricated in micro-miniatures.

AlSiMag Ceramics include many special purpose ceramics, some especially adapted to hermetic sealing. Widest choice of materials, more than half a century of specialized experience. Send blue print and operating conditions.



The AlSiMag Ceramics in these multiple pin headers may be safely used up to 2800°F. The metal components are the limiting factors.

These tantalum pins with nickel braze alloy operate around 1000° F. All materials are rugged. Strong hermetic seal. Low vapor pressure. High temperature bake-out is practical.

A Subsidiary of Minnesota Mining and Manufacturing Company

AMERICAN LAVA CORPORATION

CHATTANOOGA 5, TENN.
38TH YEAR OF CERAMIC LEADERSHIP

For service, contact American Lava representatives in Offices of Minnesota Mining & Manufacturing Co. in these cities (see your local telephone directory): Boston: Newton Center, Mass. • Chicago: Bedford Park, Ill. • Cleveland, O. • Dallas, Texas • Los Angeles, Cal. New York: Ridgefield, N. J. • Philadelphia, Pa. • St. Louis, Mo. • St. Paul, Minn. • So. San Francisco, Cal. • Seattle, Wash. All other export: Minnesota Mining & Manufacturing Co., International Division, 99 Park Ave., New York, N. Y.

How

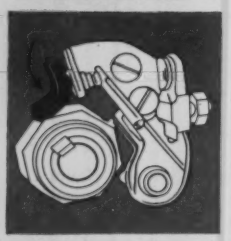
FELT

BY FELTERS

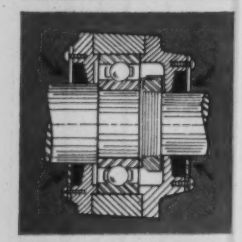
Can Improve Product

SEALING and LUBRICATION

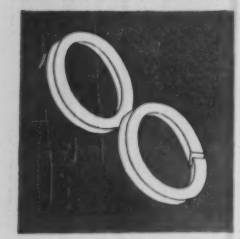
DuFelt is a laminated combination of Felters' felt and Hycar; and is recommended for sealing of lighter oils when no head exists. Seals and lubricates at the same time; and offers improvements over other materials.



Felt is an ideal wicking and lubricating material which can be designed into special assemblies like this distributor cam shown here. Lubrication is constant, wear reduced, and felt can be shaped to cover all required areas.



Lifetime bearing lubrication is now possible by selection of correct SAE grade, and designing into sealed bearing. Felt filters out contamination and works as combined reservoir and wick, directing oil flow to required areas.



Mechanical felt seals permit a close seal without undue pressure. Felt can be waterproofed and provides superior grease and oil retaining and dust, dirt and grit exclusion.

To help you get the most out of FELT, send for the Felters' Design Book. Write, today.

Ask for **FELT** *from . . .*

The **FELTERS** Co.

220 SOUTH STREET

BOSTON 11, MASSACHUSETTS

Pioneer Producers of Felt and Synthetic Non-Woven Fabrics

FE 9-18

For more information, turn to Reader Service card, circle No. 458

in transit.

The coating, called Zincilate WST-100, can be removed easily and quickly from the surfaces of metallic and nonmetallic materials by a warm water rinse. It is noninflammable, has good resistance to petroleum solvents, and withstands mild forming and shaping operations.

The inorganic coating, composition of which has not been revealed, was developed by Industrial Metal Protectives, Inc., 401 Homestead Ave., Dayton 8, Ohio. Zincilate WST-100 air dries to full hardness (Rockwell C80) in 30 min.

Low Cost Flakeboard for Gears, Insulation

Relatively low cost, resin-impregnated compressed wood flakes show promise as a competitive material for electrical insulation, gears, cams, patterns, handles, trays, seats, table tops and drain boards. This new member of the compreg-impreg family of wood products is hard, strong and dense. It has good electrical properties and good resistance to moisture and chemical attack.

But its most outstanding characteristic is its low cost compared to compreg and impreg wood products. Cost estimates made by J. W. Talbott, wood technologist at Washington State Institute of Technology, show that commercial production costs will be about $1 per sq ft for ¾-in. material.

Talbott presented engineering data on the flakeboard, called Flapreg (pronounced Flay-preg), at the 12th national meeting of the Forest Products Research Society, Madison, Wis. The data may be found in the Feb '59 issue of *Forest Products Journal*.

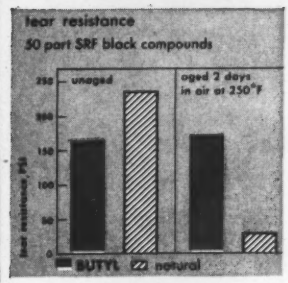
Test results indicate Douglas fir Flapreg has slightly lower modulus

PROPERTIES OF TWO WOOD PRODUCTS COMPARED

Type →	Compreg	Flapreg
Specific Gravity	1.34	1.39
Mod of Rupture, 1000 psi	15	13
Mod of Elast, 1000 psi	2290	1910
Bond Str, psi	—	1000
Water Abs (24 hr), %	1.46	0.44

ENJAY BUTYL

RUBBER FOR RESISTANCE TO TEAR AND ABRASION



Enjay Butyl offers the highest aged tear strength of any rubber. Even after long exposure to heat, oxygen and ozone, Butyl retains nearly all its original tear and flex resistance...keeps its stretch without tearing. And Butyl's inherent toughness offers rugged resistance to abrasive wear. Butyl is the preferred rubber and proven superior in such applications as conveyor belts, hoses, heavy-duty off-the-road truck tires, and other mechanical goods.

Butyl also offers...outstanding resistance to chemicals, weathering, sunlight, heat, and electricity...superior damping qualities...unmatched electrical properties and impermeability to gases and moisture.

Find out how this versatile rubber can improve your product. Call or write the Enjay Company, today!

ENJAY® BUTYL

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY COMPANY, INC., *15 West 51st Street, New York 19, N.Y.*

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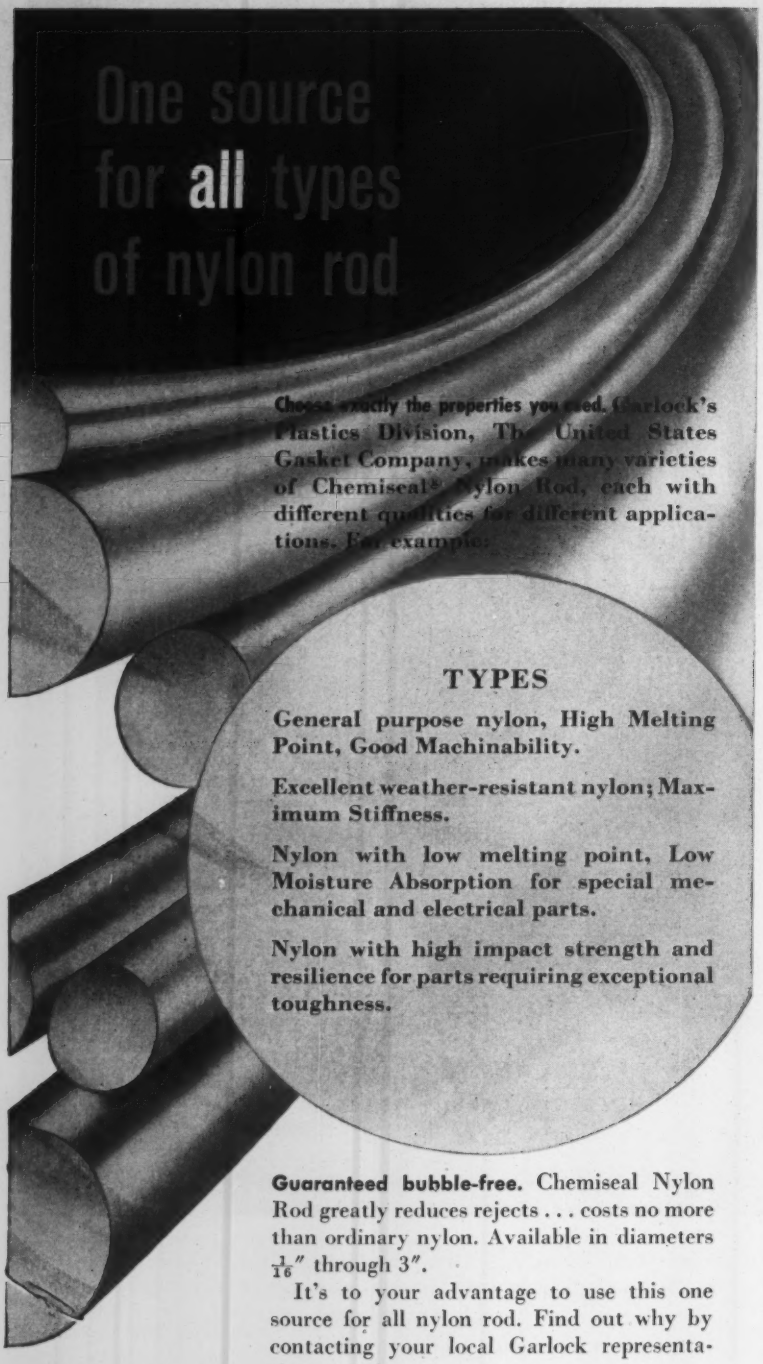

One source
for all types
of nylon rod
Choose exactly the properties you need. Garlock's Plastics Division, The United States Gasket Company, makes many varieties of Chemiseal® Nylon Rod, each with different qualities for different applications. For example:
TYPES
General purpose nylon, High Melting Point, Good Machinability.
Excellent weather-resistant nylon; Maximum Stiffness.
Nylon with low melting point, Low Moisture Absorption for special mechanical and electrical parts.
Nylon with high impact strength and resilience for parts requiring exceptional toughness.

Guaranteed bubble-free. Chemiseal Nylon Rod greatly reduces rejects . . . costs no more than ordinary nylon. Available in diameters $\frac{1}{16}$" through 3".

It's to your advantage to use this one source for all nylon rod. Find out why by contacting your local Garlock representative, or write

THE GARLOCK PACKING COMPANY, Palmyra, N.Y.

For Prompt Service, contact one of our 26 sales offices and warehouses throughout the U.S. and Canada.

United States Gasket

Plastics Division of GARLOCK

For more information, turn to Reader Service card, circle No. 446

of rupture and modulus of elasticity than Sitka spruce compreg. Flapreg absorbs about one-third as much water as does compreg after 24-hr immersion in water.

The flakeboard is very resistant to acids and organic solvents. It is attacked slowly by strong alkalis. The material, in higher densities, is completely cigarette-burn-proof: the only effect from a burning cigarette is a brown stain of condensed tars which can be easily wiped off with an organic solvent.

Fabrication

Flapreg, in common with compreg, can be readily worked with high speed steel or carbide tools. It sands easily, takes a high polish, and needs no varnish or other finish for most applications. Screw holding is excellent with self-tapping machine screws. Strong bonds can be made with thermosetting adhesives.

How product is made

Fully impregnated and compressed flakeboard is produced in six steps:

1. Preparation of wood flakes.
2. Initial drying of flakes.
3. Resin impregnation of wood flakes.
4. Re-drying of resin-impregnated flakes.
5. Machine felting.
6. Pressing and curing.

In contrast, impreg is made by curing, gluing and pressing resin-impregnated and dried wood veneers. Compreg is made by gluing resin-impregnated and dried wood veneers in the uncured condition and pressing at high temperatures and pressures. Both impreg and compreg wood products are high in materials cost because high grade wood veneers are required. They are also high in labor costs because of the repeated handling of the individual wood veneers.

Silicone Rubber Tape Seals Out Weather

A new silicone rubber compound designed for use in the fabrication of semi-cured electrical tapes is now available from General Electric Co., Silicone Products Dept., Waterford, N. Y. GE says open-type motors insulated with the material can be used outdoors. The silicone compound

For more information, circle No. 521 ➤

On cars of TOP PRESTIGE and HIGHEST VOLUME

you'll find **wheel covers** of

Superior
STAINLESS STEEL

Leadership demands the best in performance . . . and only stainless steel will do for the gleaming wheel covers of leading cars. We are most proud that SUPERIOR Stainless Strip Steel is used in the fabrication of wheel covers by Brown-Lipe-Chapin. Every stainless quality is in our product, plus the finer forming behavior that is traditionally Superior. Let us discuss your stainless strip requirements.

SUPERIOR STEEL DIVISION

OF

COPPERWELD STEEL COMPANY

CARNEGIE, PENNSYLVANIA

For Export: Copperweld Steel International Company, New York

The wheel covers illustrated were fabricated by Brown-Lipe-Chapin Division, General Motors Corporation, Syracuse, New York.

Ideas for missile engineers

Hackney components—deep drawn shapes, shells and parts—offer designers many advantages, including:

- great strength with minimum weight
- elimination of heavy castings, forgings, etc.
- maintenance of exact diameters, wall thicknesses
- simplification of assemblies to speed installations
- naturally smooth surfaces which are easy to paint, clean, maintain
- making parts in ten different metals
- maximum latitude in designing; for example, wall thicknesses .050" to .700"...working pressures to 600 psi...as well as ample design latitude in capacities, diameters and depths

For engineering facts, data on components already produced by Hackney engineers for missile and rocket projects, write to the address below.

Pressed Steel Tank Company

Manufacturer of Hackney Products Since 1902

1442 South 66th Street, Milwaukee 14, Wisconsin

Branch offices in principal cities

CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

Hackney

DOMINION IRON WORKS

For more information, turn to Reader Service card, circle No. 490

What's new IN MATERIALS

PROPERTIES OF SE-1010U•

Tensile Strength, psi	900
Elongation, %	340
Tear Strength, psi	75
Hardness (Durometer)	A60

•Specimen oven cured 24 hr at 480 F.

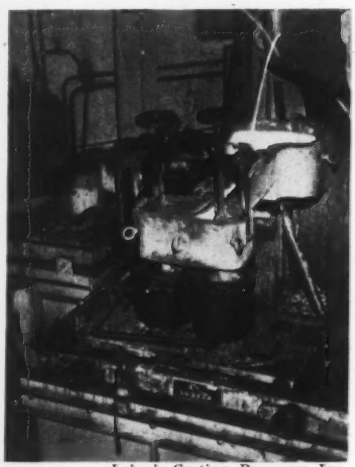
is called SE-1010U.

Semi-cured electrical tapes made of SE-1010U are said to have good bond strength, good shelf life, good shock, abrasion and vibration resistance, and excellent corona resistance.

Copper Tubing Made from Improved Billets

High quality copper tubing for refrigerators, air conditioners and other products is being extruded from copper extrusion billets made by a new semi-continuous casting technique. Billets produced by the technique are said to have superior surface finish and good internal structure.

The casting technique, developed by Lobeck Casting Processes Inc. and now in operation at Halstead Metal Products Inc., Zelienople, Pa., uses two semi-continuous casting machines mounted in tandem and fed with liquid metal from an electric



Lobeck Casting Processes Inc.

Casting *two phosphor de-oxidized copper billets for subsequent extrusion into tubing.*

For more information, circle No. 511 ➤

WHAT CAUSES YOUR MATERIAL APPLICATION PROBLEM?

Abrasion? Corrosion? High Temperature?

When you have the problem of selecting a material to use for a part which will be subjected to corrosive, abrasive or high temperature conditions that are destructive to metals, you may find your solution by specifying one of the COORS SPACE AGE CERAMICS.

Other design engineers in many industries are specifying COORS SPACE AGE CERAMICS for a wide variety of uses for which, normally, only the more expensive alloy steels or specialty metals could be expected to get the job done.

COORS SPACE AGE CERAMICS regularly specified for industrial applications consist basically of aluminum oxide (Al_2O_3) which is "alloyed" with other ingredients, according to formulations developed by Coors, to produce ceramic compositions having specific physical and electrical properties. The physical properties of four of these Coors materials are listed in the accompanying table.

To some engineers the mention of "ceramics" brings to mind a weak, fragile type of material good only for flowerpots or cups and saucers. That is understandable because most of us have had reason to be cautious in the handling of porcelain and china dishes.

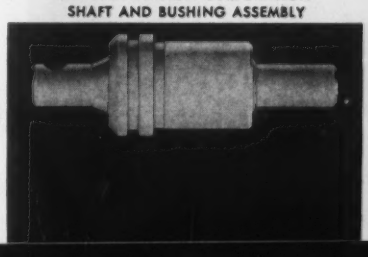
The word "ceramics" bears the same relation to the Ceramics Industry that the word "iron" bears to the Iron and Steel Industry. For thousands of years the Ceramics Industry made little progress while the Iron and Steel Industry was moving forward—developing from ordinary "pig iron" a whole family of alloy steels which bear little resemblance to pig iron.

In recent years, however, the Ceramics Industry, under the impetus of an insistent and increasing demand for materials which will withstand severe corrosion, erosion and temperatures beyond the range of metals, has made giant strides in developing techniques and new materials suitable for Space Age uses.

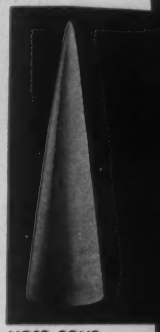
COORS PORCELAIN COMPANY has been the leader in perfecting new manufacturing techniques and new ceramic materials for the Space Age.

The famous Isostatic Process for forming homogeneous, "stress free" products was perfected by Coors for use in the production of mechanical and electrical parts for industrial equipment. This made possible the development of Coors High Strength Ceramics and their use for applications where, formerly, only metals could be used.

BENDIX AVIATION CORPORATION
SHAFT AND BUSHING ASSEMBLY



In addition to the Isostatic Process, Coors employs all other recognized methods for the production of ceramic parts and, therefore, is in a position to select the production technique best suited for a specific job.



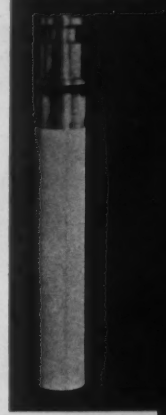
NOSE CONE

Coors production facilities are capable of turning out products ranging all the way from a crude ball mill lining brick to high precision gauge blocks.

An indication of the type of high precision work that can be done by Coors is the shaft and bushing assembly made for Bendix Aviation Corporation and illustrated here. On this assembly, dimensional tolerances are held as close as ±0.000015".

Applications for COORS SPACE AGE CERAMICS are found in all major industries where ordinary materials do not stand up.

Parts made of these ceramics are found in a wide range of equipment—from atomic submarines to missiles. Some of the applications include pump plungers for pumps used in the oil, chemical and other industries; cylinder liners for pumps; orifices and nozzles for many types of equipment subject to abrasion; oil well tubing protection sleeves; wire guides; rollers; cups for gas-arc welding equipment; valve parts; mechanical shaft seal parts; wear plates; welding locators; extrusion dies, etc.

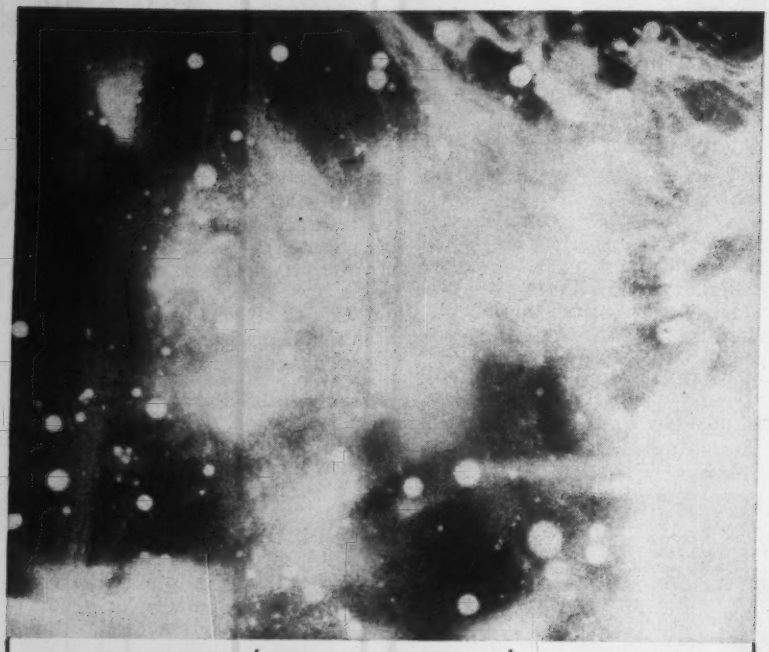


PUMP PLUNGER

MECHANICAL SEAL RING

Coors offers a complete engineering service to assist you in utilizing these high strength ceramics to the best advantage. For complete specifications, write for Bulletin 858.

Coors
COORS PORCELAIN COMPANY
600 Ninth St., Golden, Colorado



ZEUS / DELTA / ALBM

These and other vital missile and space projects at DOUGLAS have created prime opportunities for

WELDING ENGINEERS and
METALLURGICAL ENGINEERS
(B.S., M.S. or Ph.D.)

Several outstanding openings exist in production, development and research. Areas include fusion welding and design consultation. Aircraft or missile experience is preferred but is not mandatory.

DOUGLAS

For full information contact
C. C. LaVene, Box 621-H
Douglas Aircraft Company
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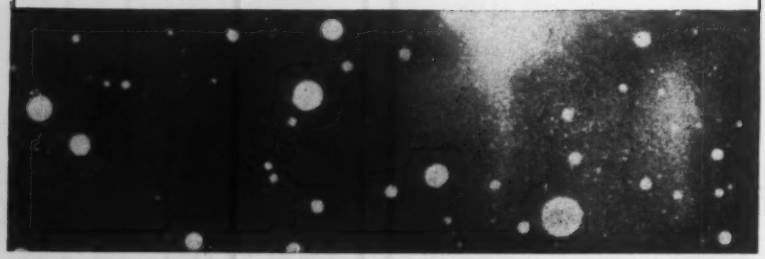
The most respected name in aircraft, missile and space technology



For more information, turn to Reader Service card, circle No. 477

arc furnace.

In producing the billets, molten de-oxidized copper is conveyed from the furnace to a double mold. An "underpouring" method used to introduce the molten metal into the mold is said to exclude internal porosity and inclusions in the copper billet. When the castings reach a length of 12 ft, the metal flow is switched from the first casting machine to the second.

Seven New Tapes Are Easy to Apply

Seven pressure sensitive tapes, including urethane foam, paper, TFE, fiberglass and PVC-coated cloth tapes, are said to be easy to apply to metals and nonmetals.

Urethane foam tape

The urethane foam tape is a product of Richards, Parents & Murray, Inc., 312 7th Ave., New York 1. According to the developer, a pressure sensitive adhesive holds the tape in place at fluctuating temperatures from 0 to 300 F. Both the urethane foam and the adhesive are noncorroding and impervious to moisture.

The tape is said to have good sound and heat insulating properties,

M/DE'S NEW EDITOR

We are pleased to announce that Mr. Donald Peckner, formerly of Westinghouse Electric Corp., has recently joined our editorial staff as Associate Editor.

At Westinghouse, Mr. Peckner was associated with the Metallurgy Dept. of the Materials Engineering Departments in East Pittsburgh, Pa. This group acts essentially as consulting metallurgists for the Corporation. Mr. Peckner has been the author of a considerable number of published technical articles, and has been active in the American Society for Metals.

A metallurgical engineering graduate of Polytechnic Institute of Brooklyn, Mr. Peckner served in the Army Ordnance Corps during the Korean conflict. He is 31, and has a wife and two children.

For more information, circle No. 413 ➤

Specialty Steel Stocks . . . to Serve You Better

To give you still faster service on "we-need-it-yesterday" orders for specialty steels, Ingersoll now maintains substantial stocks of stainless, high speed and alloy sheets, plates and ingots. In many cases, your order can be filled and on its way in a matter of hours. And because Ingersoll is a specialty mill, you get quality you can depend on to meet your analysis, size and thickness specifications. Call us now for your needs.

STAINLESS STEELS • HEAT RESISTING STAINLESS • INGACLAD STAINLESS-CLAD SHEETS • ALLOY STEELS • FORGING QUALITY ELECTRIC FURNACE INGOTS TO 23,000 POUNDS • AUTOMOTIVE CLUTCH PLATE STEELS • CROSS-ROLLED STEEL • CARBON ELECTRIC STEEL FOR TRACTOR CLUTCH DISCS • KNIFE STEELS • SAW STEELS • HIGH SPEED HACK SAW STEELS • SOFT CENTER AND OTHER AGRICULTURAL STEELS • SPECIAL ANALYSIS STEELS

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REDUCE MANUFACTURING COSTS

IMPROVE PRODUCT PERFORMANCE

SOLVE DESIGN PROBLEMS

with

WORLD BESTOS

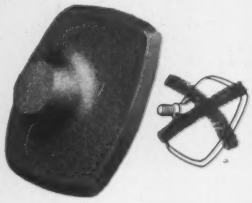
MOLDED ORGANIC PARTS

REDUCE COSTS

High-density molded organic part replaces brass pressure plate in clutch assembly

IMPROVE PERFORMANCE

Semi-flexible molded organic parts replace leather washers in deep well pump



SOLVE DESIGN PROBLEMS

Resilient molded organic part replaces combination metal-hard rubber vibration damper

● A fresh approach to design problems with WORLD BESTOS Molded Organic Parts can pay off in improved product performance and reduced manufacturing costs. Applications range from industrial and automotive equipment to home appliances. Molded Organic Parts can be built to meet virtually any shape, size or performance specifications. Parts can be supplied for testing and evaluation or on a production basis. For complete details, send samples or blueprints to WORLD BESTOS, New Castle, Indiana. Phone Jackson 9-4790.

WORLD BESTOS NEW CASTLE INDIANA

DIVISION OF THE Firestone TIRE AND RUBBER CO.

Industrial and Automotive Brake Blocks and Linings · Transmission Linings · Special Clutch Facings · Vibration Controls · Sheet Packing

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and good chemical, shock and vibration resistance. It is especially useful for cushioning delicate instruments, for weather sealing glass partitions, for sound proofing automobiles and typewriters, and for sealing air conditioners.

Two paper tapes

Two paper tapes with a pressure sensitive adhesive are available from Permacel-LePage's, Inc., U. S. Hwy. No. 1, New Brunswick, N. J. The tapes, EM-3979 and EM-4082, are reported to have good high and low temperature resistance properties, and good stain resistance. They are recommended for use in refrigerators, freezers and cold storage lockers.

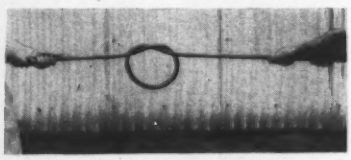
TFE tape

Type LT is the name of the new TFE tape introduced by Dilectrix Corp., Allen Blvd., Farmingdale, N. Y. The developer says a very slight pressure will adhere the tape to wood, rubber, plastics, metals and glass. The tape is recommended for electrical and electronic applications. It is available in thicknesses from 0.002 to 0.004 in., and in widths from ¼ to 12 in.

Two fiberglass tapes

Connecticut Hard Rubber Co., 407 East St., New Haven 9, Conn. is marketing two fiberglass tapes under the name Temp-R-Tape.

GV is a fiberglass tape designed for use in the construction and repair of electrical equipment operating at high temperatures. It has a



Strong welded steel tubing — A line of welded steel tubing designed especially for heat exchangers has been placed on the market by Babcock & Wilcox Co., Tubular Products Div., Beaver Falls, Pa. According to the developer, the tubing can literally be tied in a knot (as shown above) without damage. The tubing, called Lectrosonic, is formed from flat steel strip, with the edges joined by electric resistance welding.

Designing for HIGHER PERFORMANCE?

. . . consider the advantages of ALITE

If you are designing a new product, or seeking new ways of improving existing ones, designing for Alite high-alumina ceramic may be your most profitable approach.

Because of its unique physical, chemical and electrical properties, this rugged and versatile material has proved successful in many highly critical applications, thus solving difficult design and production problems in a wide range of industrial fields.

Alite withstands high heat, shock and abrasion. Permits you to design for higher temperatures and greater strength. It can be supplied in practically any shape, finished to exacting tolerances. Alite has excellent properties for use as bushings, bearings, valve seats, pump parts, wear plates, wire guides, spools and cores. Any job that demands high mechanical strength and wear resistance, chemical resistance, or reliable performance at elevated temperatures, is a possible application for Alite.

Important ALITE properties

- Extremely hard, strong, chip-resistant
- Chemically inert—cannot rust or corrode
- Vacuum-tight—can be metalized and bonded to metal for hermetic seals
- High thermal shock and heat resistance—working temperatures to 1600°C.
- Remains stable under nuclear radiation
- Low thermal expansion
- Excellent dielectric characteristics

For complete description of Alite, plus data on Alite Ceramic-to-Metal Seals, write for Bulletins A-7R and A-20.

117-F

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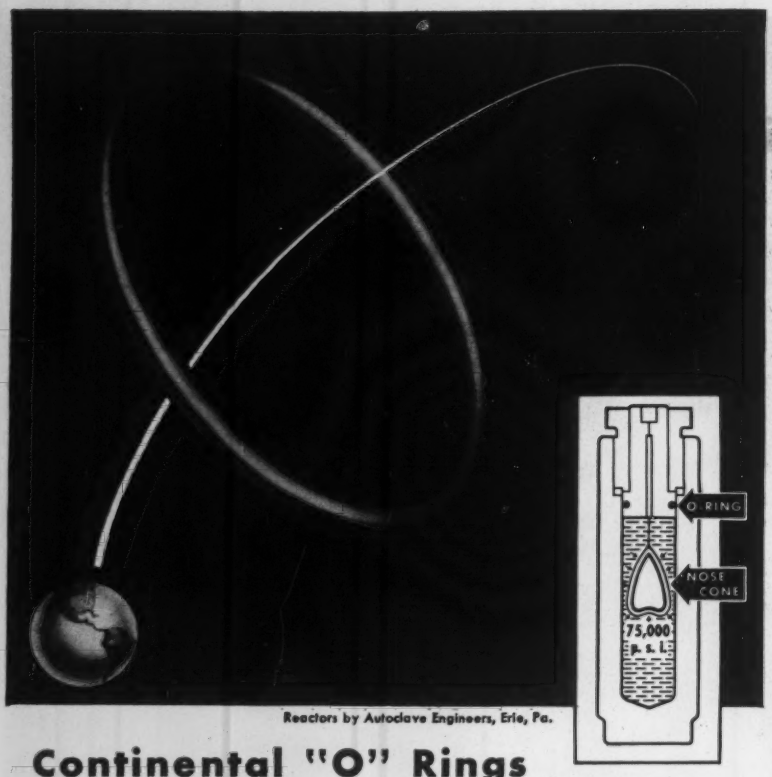

Reactors by Autoclave Engineers, Erie, Pa.

Continental "O" Rings Help Put Satellites in Orbit

Almost as dramatic as the thrust of a satellite into outer space is the technique used to fabricate the nose cone of the missile. These nose cones, made either of powdered metals or refractory materials, are being compacted in 12" I.D. pressure vessels under hydrostatic pressure of 75,000 P.S.I. *Imagine the problem involved in sealing a vessel against such terrific pressure!*

Yet *THAT* is the problem solved by this Continental "O" Ring. Obviously an ordinary "O" Ring would not do. The job called for a special compound with molecular formation so precise that separation or micro-leakage just could not occur. Continental developed the compound that meets this rigid test. What's more, the elasticity of the rubber refuses permanent set and thus permits re-use of the ring.

This unusual rubber problem typifies the complete engineering service available to you here at Continental. Whether you need molded or extruded rubber parts, consult with us *while your new products are still on the board.* Let us suggest how you might save both tooling and material costs—and get a better product for the job.

Hydrostatic Pressing (see diagram).

A technique for producing uniform compaction and grain structure to obtain super hardness and impact resistance in critical components. A steel forming-mandrel is coated with a refractory material, placed in a rubber bag and suspended in pressure vessel. Pressure is applied until required density is attained.

Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**
engineered by **CONTINENTAL**

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heat curing, pressure sensitive silicone rubber adhesive that is said to withstand operating temperatures as high as 500 F. The tape is available in widths from ½ to 2 in.

TGV is a TFE-impregnated fiberglass tape designed for use in mechanical and electrical applications. The tape has good wear resistance and is dimensionally stable at high temperatures. It adheres to any dry, clean surface. The TFE-fiberglass tape is supplied in widths from ½ to 2 in.

PVC-coated cloth tape

A PVC-coated cloth tape called 676 is available from Permacel-LePage's, Inc., U. S. Hwy. No. 1, New Brunswick, N. J. It is specifically designed for joining and sealing sections of ductwork in heating, ventilating and air conditioning systems.

Stronger Steels Sought for Missiles, Rockets

Although ceramics, plastics and nonferrous metals are finding increased use in rocket and missile parts, two recent developments show the continued interest in improving the efficiency of steel for such applications.

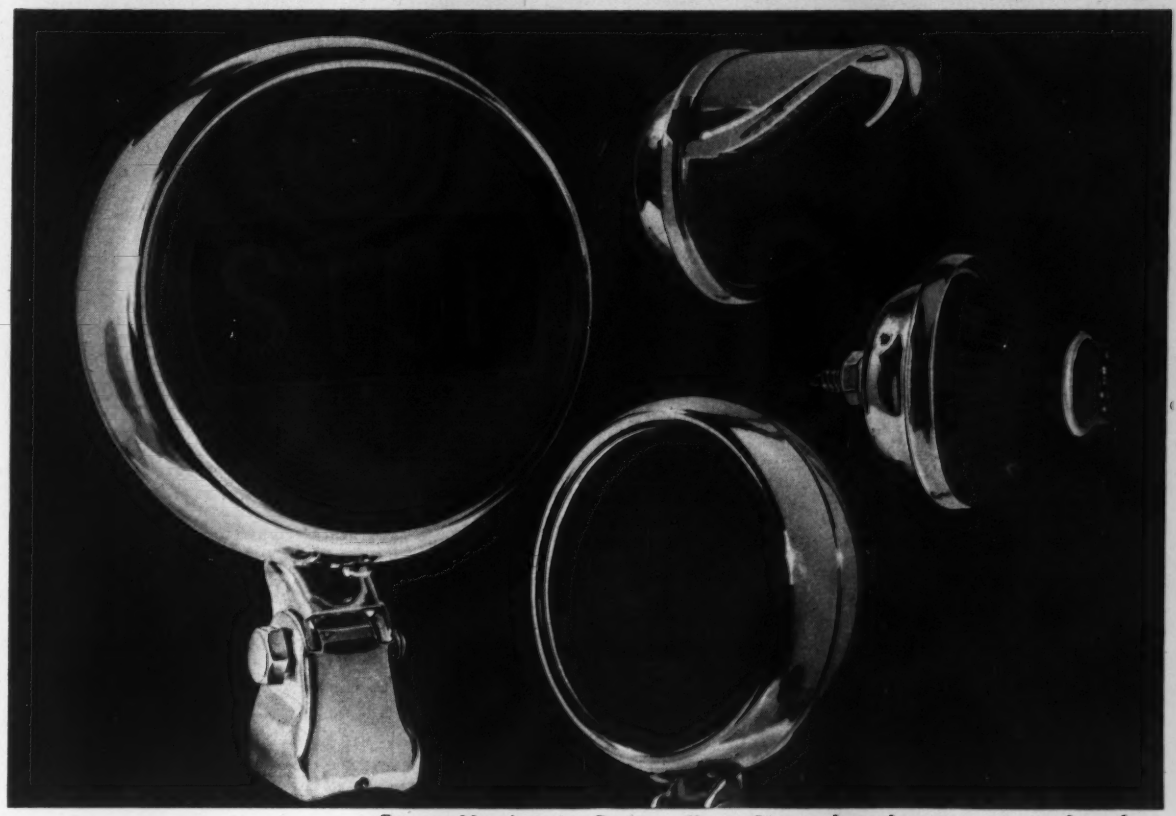
Steel strip

Jones & Laughlin Steel Corp., Stainless and Strip Div., Detroit 34 announced that it has been awarded a development contract by Aerojet-General Corp., Azusa, Calif. for an "extremely high strength steel strip" for use in rocket and missile parts. Specification targets call for mechanical property requirements to far exceed the properties obtainable with present day steel strip. After the initial development program, a limited amount of the material will be furnished Aerojet-General from J&L's Youngstown, Ohio plant.

Sheet steel

Lockheed Aircraft Corp,, 745 Chrysler Bldg., New York 17 announced that its Georgia Div. will build and test two rocket fuel cases made from U. S. Steel's new air hardening, high strength steel called Airsteel X200. The steel, discussed in a previous issue of this magazine

BRIDGEPORT BRASS STRIP...



Peterson Manufacturing Company, Kansas City, produces the auto accessories shown here.

STOPS Rising Production Costs of Vital Automotive Accessories

Spotlights, stop lights, reflectors and a host of vital auto accessories are most economically produced from Bridgeport Cartridge Brass Strip (Alloy 69). The ease with which Alloy 69 can be formed is the key to the cost savings. In fact, Cartridge Brass has replaced stainless steel in many of these applications.

Superior deep-drawing properties in Cartridge Brass make it possible to reduce the number of forming operations to a minimum. Rejects are also eliminated, for Alloy 69 has the ductility and strength to take progressive forming operations without rupture or cracking. And the finish remains fine during processing – fine for the chrome plating needed to give auto lamps reflective brilliance. The added plus of high scrap value for brass gives manufacturers a final dollars-and-cents reason to lower manufacturing costs by forming parts from a forming material—Cartridge Brass Strip.

Lamps are not the only products that save from the formability of Cartridge Brass Strip. Grillwork and grommets, snap fasteners and spun products, eyelet machine items and every progressively formed product can enjoy minimum unit costs with this one-of-a-hundred Bridgeport Metals. For a complete list, and mechanical-physical properties comparison, write today for a copy of the folder, "Bridgeport Alloys, Copper, Brass, Bronze." Please address Dept. 3505.

BRIDGEPORT BRASS COMPANY

Bridgeport 2, Conn. • Sales Offices in Principal Cities

Specialists in Metals from Aluminum to Zirconium

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MOSINEE MAKES MAGIC WITH PAPER

Char Test favors

MOSINEE Flame-Resistant Papers

- Mosinee flame-resistant papers consistently test less than the minimum requirements of 4½" char when subjected to U.S. government specification test methods.
- Special flame-resistant process, developed by Mosinee laboratories, can be applied to many of our papers.
- Ideal for paint arrestors, furnace filters, insulation, drop cloths, covers for stored goods, and packing and wrapping papers.
- You get the same high Quality from roll to roll . . . from carload to carload.

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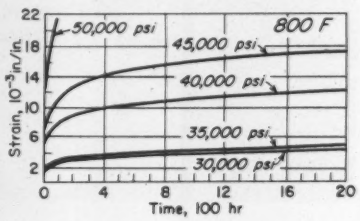
(see M/DE, Dec '58, p 124), can be air hardened and tempered to a tensile strength of 280,000 psi. It will be supplied in the form of large, close tolerance sheets (10 x 12½ ft). The large sheets will be produced by a special sandwich rolling technique.

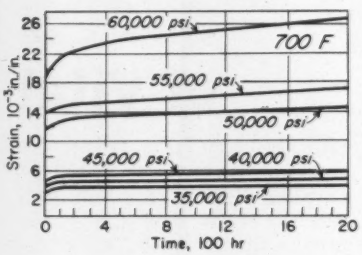
Lockheed's evaluation of the steel will include studies to determine its response to heat treatment, its weld ing characteristics, and its ability to withstand high biaxial tension loads and compression stresses.

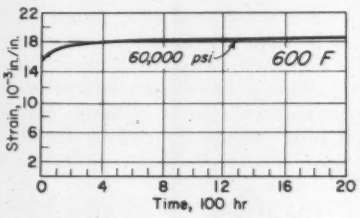
Creep Data on ASTM Type A-302 Steel

by F. W. Wiesinger

The graphs below and the table on p 174 show the results of creep tests conducted on ASTM Type A-302, Grade B, manganese-molybdenum fire box steel. The creep tests







Creep curves *for A-302 at three temperatures*

Jet brake cup — LS-53
Synthetic lube diaphragm — LS-53
Diesel equipment seal — Viton
Drop-off tank seal — LS-53
Chemical pump liner — Viton
Natural gas valve diaphragm — Viton

For advanced fuel...hydraulic...lube systems,

New materials prove ideal in handling temperature extremes −350° F. to +750° F.

Working with two remarkably versatile elastomers, C/R Sirvene engineers are producing flexible molded parts for many vital fuel, lubricating, hydraulic and pneumatic systems. One, Viton-A*, can be compounded to produce parts that function dependably at 600° F., and for short periods up to 750° F. The other important feature of Viton compounds is their excellent resistance to corrosive chemicals, chlorinated solvents as well as both synthetic and petroleum base fuels and lubes. At the other extreme, C/R compounded Silastic LS-53** parts are providing low temperature operation down to -80° F. They also exhibit excellent resistance to synthetic and petroleum base fluids up to 350° F., and function well in propane up to 500° F. For temperatures as low as -350° F., C/R recommends Teflon* compounds.

C/R Sirvene engineers have an intimate knowledge of these elastomers. They also have perfected special techniques in processing which still further improve the physical properties of the molded parts. If your problem involves high or low temperatures, close tolerances, and compatibility in advanced design fuel, lubricant or hydraulic systems, get in touch with us at once. We have the skill and the facilities to help you.

* DuPont registered trademark
**Dow-Corning registered trademark

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SIRVENE DIVISION, 1227 ELSTON AVENUE • CHICAGO 22, ILLINOIS
Offices in 55 principal cities. See your telephone book.
In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario
Export Sales: Geon International Corp., Great Neck, New York
C/R PRODUCTS: C/R Shaft & End Face Seals • Sirvia-Conpor mechanical leather cups, packings, boots • C/R Non-metallic gears

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why
Edgewater
rolled steel rings
are best . . .
A solid steel block is heated to forging temperature, and thoroughly soaked.
The block is upset on a forging press, and the center is punched out.
On the rolling mill, the heated punched block revolves between main and pressure rolls, where its diameter grows and section shape is formed. Edging rolls control width.
Below—representative sections of rings rolled by Edgewater

From a solid block of steel, a solid ring has been formed, to required size and shape. The accuracy possible with this process greatly minimizes the need for further finishing. Diameters are from 5 to 145 inches, weights up to 14,000 pounds. Materials include carbon and alloy steels, stainless, tool steels, titanium. Facilities available for machining and heat treatment.

Write for descriptive bulletin.

Edgewater Steel Company

Dept. MDE · P.O. Box 478 · Pittsburgh 30, Pa.

For more information, turn to Reader Service card, circle No. 400

What's new IN MATERIALS

CREEP DATA ON A-302 STEEL

Stress, psi	Min Creep Rate, 10^{-4}%/hr	Total Plastic Strain (2000hr)
800 F		
50,000	—	—
45,000	1.20	0.01603
40,000	0.98	0.01092
35,000	0.31	0.00320
30,000	0.25	0.00312
700 F		
60,000	1.67	0.02524
55,000	1.15	0.01534
50,000	0.68	0.01339
45,000	0.26	0.00451
40,000	0.11	0.00356
35,000	0.16	0.00294
600 F		
60,000	0.40	0.01773
55,000	0.28	0.00537
50,000	0.27	0.00807
45,000	0.25	0.00850

COMPOSITION OF A-302 STEEL

Carbon	0.250
Manganese	1.380
Molybdenum	0.450
Phosphorous	0.016
Sulfur	0.034
Silicon	0.240

were run at 600, 700 and 800 F.

Object of the tests was to determine the applicability of Type A-302 steel for use as a pressure vessel material for nuclear reactors. Such a vessel would be subjected to stresses at temperatures approximating 600 F. Ordinarily, creep is not considered a problem at temperatures below 800 F; however, engineering data were required for the design of the pressure vessel.

Data from the creep tests show that 600 F is too low a temperature for creep studies on this material; results were erratic and unrealistic. The data show that creep curves can be determined with reliability at 700 and 800 F.

Some details on test procedure: The manganese-molybdenum fire box steel was normalized at 1650 to 1700 F for 2½ hr. Creep specimens, 0.390 in. in dia by 7 in. long were machined from the material. The

The author is associated with Knolls Atomic Power Laboratory, Schenectady, N. Y., operated for the Atomic Energy Commission by General Electric Co.

Spray dryer wheels get longer life from titanium

Titanium is chalking up large savings as a material for process industries equipment. Its corrosion resistance, strength and light weight, and easy machinability all add up to economies.

For example, the atomizer wheels, as shown above, are vital components in spray dryers manufactured by Bowen Engineering, Inc., North Branch, N. J. They turn at selected speeds between 6000 and 20,000 rpm, blasting feed liquid into f. ıe spray to be dried by heat.

In one installation, a titanium wheel operated 2200 hours in hot calcium hypochlorite. With previously used materials the entire wheel had to be replaced after this service but only the outer basket of the titanium wheel needed replacement. In addition, the light weight of titanium greatly reduced wear on bearings in this high speed rotating part, producing further savings.

To learn more about titanium, in new, profitable applications, write us. We can show you how this light, strong, corrosion-resisting metal is coming of age as an economical answer to difficult corrosion problems.

Union Carbide Metals Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. *In Canada:* Union Carbide Canada Limited, Toronto.

UNION CARBIDE METALS

***Electromet** Brand Ferroalloys and other Metallurgical Products*

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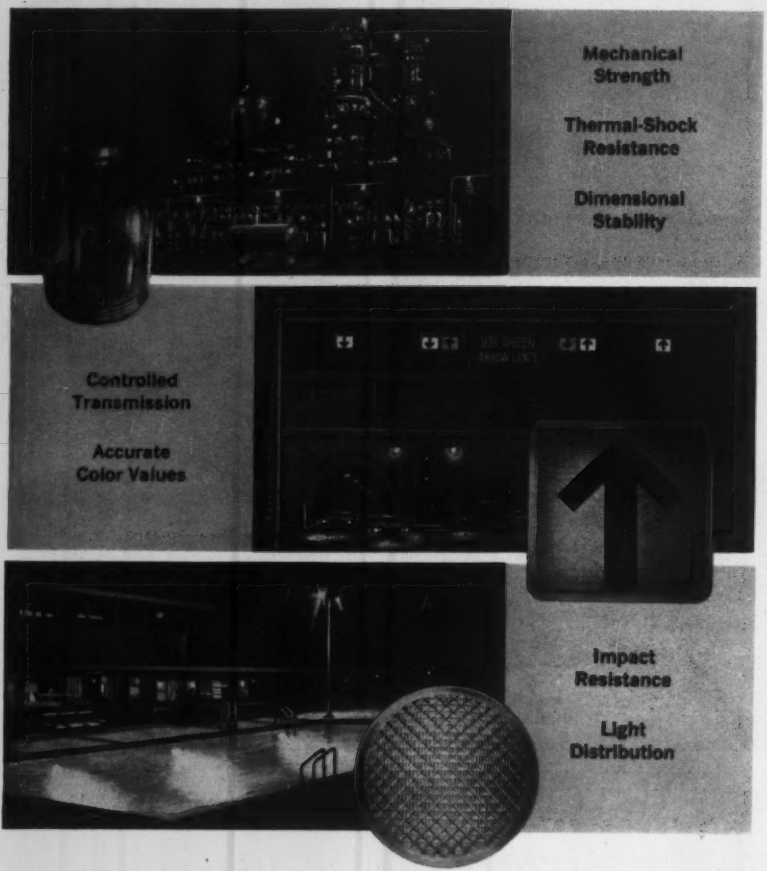
try GLASS

...there are so many advantages



Kopp Engineers help you get the right combination to meet your specific application requirements

Glass has so many useful and desirable properties and the extent to which these can be varied and controlled opens up almost unlimited design possibilities. That's where Kopp's engineering service comes in. Whether you require explosion-proof indicator lenses, heat-resisting lenses for swimming pools, floodlight cover glass, or traffic control lenses—Kopp has the engineering experience and manufacturing know-how to help you meet these requirements—*exactly*. Write us about your needs. Ask for Bulletin 553-A.

Specialists in engineered, custom-made glass KOPP GLASS

Kopp Glass, INC.

Swissvale, Pennsylvania

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specimens were annealed in evacuated quartz containers at 1250 F for 1 hr, then air cooled. After annealing the specimens were inserted in "Barker" creep furnaces. Tensile stress was applied to the specimens by means of dead weight loading in 5-lb increments. Tests were conducted for a minimum of 2000 hr.

Polyethylene Extruded into Long, Thick Sheets

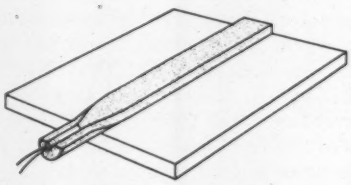
Equipment for the automatic, uninterrupted extrusion of 48 x 96-in. polyethylene sheet in thicknesses up to 1⅛ in. has been designed and built by engineers at Westinghouse Electric Corp.'s Micarta Div., Hampton, S. C.

Thick polyethylene sheet has good neutron shielding capacity and is widely used for neutron shielding on reactors where weight and space limitations are a primary consideration. The capacity of the extrusion equipment is about 6,000,000 lb per year.

Metals Cut, Hardened with Sheet Explosive

Explosive cutting and hardening of metals and other materials is made possible by the development of a new flexible sheet explosive that is said to be safe and easy to handle. These two new uses of explosives in industry join explosive forming, punching, fastening, engraving and testing methods, as reported in the Feb '59 issue of this magazine (p 82).

The new explosive, first in a series of high explosive compositions, is called EL-506A. It is available in commercial quantities from E. I. du Pont de Nemours & Co., Inc., Ex-



***Basic method** of using sheet explosive to cut metal, other materials.*

"How Jessop Stretches Specialty Steels"

Robert Timko, Metallurgist

"At Jessop, tensile testing of specialty steels is carried out with far more than ordinary precision. It pays. It's one of the reasons our repeat business is so high.

"Based on a series of photographs, this drawing shows a specimen of type 304 annealed stainless steel bar at the climax of a tensile strength test. Moving apart, the heads of the tensile testing machine stretched the bar until it finally ruptured at 5500 psi above the spec."

In this Jessop metallurgical laboratory, top metallurgists using all types of modern testing equipment help us make certain you get *consistent* high quality in specialty steels. *Specify Jessop . . . and then relax.*

VMA 6788

Tensile testing machine in the Jessop metallurgical lab. Stretch, strain and then bang! The specimen of type 304 annealed stainless bar ruptured at 5500 psi above the spec. Tensile strength okay!

In the Jessop metallurgical lab, this tensile testing machine is one of many types of tools used to make certain you get *exactly* what you want in specialty steels.

Jessop Steel International Corporation
Steel Warehousing Corporation, Chicago
Green River Steel Corporation
Jessop Steel of Canada, Ltd.

JESSOP
STEEL COMPANY
Washington, Pennsylvania

Stainless, alloy, cast-to-shape, clad and forging steels, ground flat stock and other specialty steels

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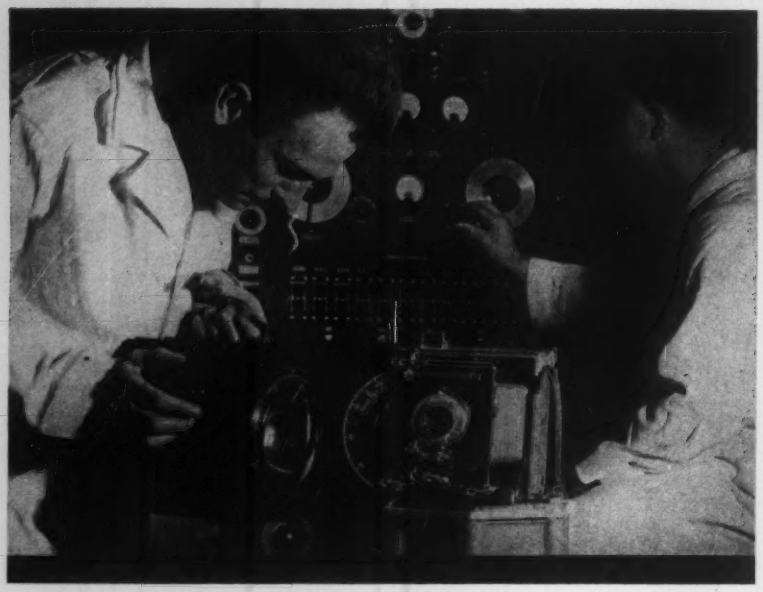

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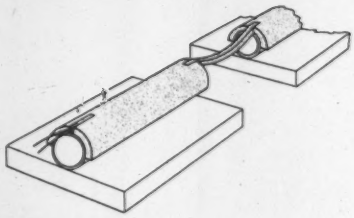


Shaped charge *with metal liner provides exceptional cutting ability.*

plosives Dept., Sales Development Section, Wilmington 98, Del. The explosive is pentaerythritol tetranitrate (PETN) combined with other ingredients. It is supplied in sheets 10 x 20 in. in a variety of thicknesses.

Two cutting methods

Basic method: In cutting metal or other materials, a strip of EL-506A is fastened as a flat strip in the pattern of the cut to be made. The width of the strip should be approximately twice the thickness of the material to be cut.

Shaped charge: Another way to cut metals and other materials with the sheet explosive is by using a shaped charge with a metal liner. The shock wave produced by the detonation of the explosive collapses the metal liner which forms a high velocity jet with great penetrating power.

Hardening

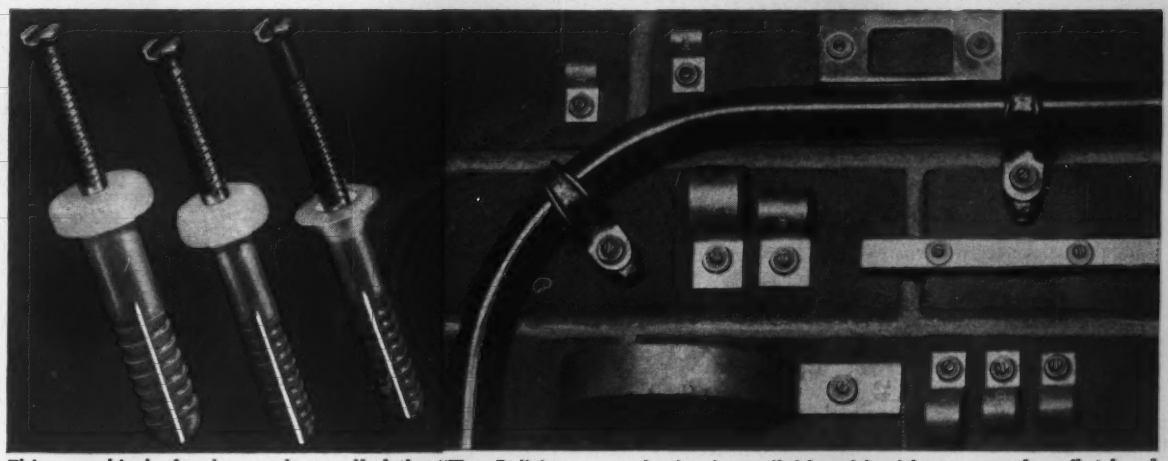
Castings and parts made of manganese steel can be prehardened by inducing a shock wave in the metal through detonation of a sheet explosive placed directly on the metal's surface. High energy fuel, rather than explosives, has also been used successfully to surface harden steel.

Because the sheet explosive is unaffected by immersion in water, it lends itself well to underwater demolition work.

Resin Cuts Cure Time, Improves Butyl Rubber

A bromo-methyl alkylated, phenol formaldehyde resin cuts cure time and improves heat resistance and compression set properties of butyl rubber. The new material also im-

New ideas in NYLON



This new kind of nylon anchor, called the "Tap-It," is molded from Spencer Nylon. Produced in three sizes, each size is available with either a round or flat head (left). Photo at right shows variety of installations.

New "Tap-It" Anchor Made of Spencer Nylon Is

Tough As Metal, Yet Won't Rust, Corrode Or Conduct Electricity

Designing a new kind of wall anchor presented a unique materials problem to Robert Q. Partridge Products, Inc. of Miami, Fla. This anchor required a material not only tough enough to withstand the direct pull of over 280 pounds, but one that would not corrode, rust or conduct electricity.

The answer to this problem was found in the special properties of Spencer Nylon. Thorough testing of the pull-out and shear strength of anchors made of Spencer Nylon proved them to be equal or superior to other types. Unlike many materials, however, Spencer Nylon will not rust or corrode, or conduct electricity or vibration. Also, Spencer Nylon is unaffected by atmospheric conditions, fungus, alkalies and chemicals.

Because of the advantages of Spencer Nylon, it is now being used by the Miami firm to mold the "Tap-It" Nylon Anchor. Sold with a threaded expansion pin, this revolutionary anchor is gaining wide acceptance among contractors, plumbers and electricians. Installation requires only the drilling of an anchor hole and a tap of the pin. The anchor is virtually impossible to remove by force, but is easy to remove when the pin is extracted.

Three sizes of "Tap-It" Nylon Anchors are available: 3/16 by 1 inch, ¼ by 1 inch, and ¼ by 1½ inches. For complete information write Robert Potruch, Robert Q. Partridge Products, 7080 NW 37th Court, Miami, Fla.

For more information about the properties of Spencer Nylon and how they may help you solve a materials problem, contact Spencer Chemical Co., Dwight Bldg., Kansas City 5, Mo.

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parts tack to butyl. The resin, designated SP-1055, is now commercially available from Schenectady Varnish Co., Inc., Schenectady, N. Y.

According to the developer, the new resin makes it possible to cure butyl rubber in 10 to 60-min cycles at 300 to 350 F. Flex life and fatigue characteristics of butyl containing SP-1055 resin are also better than those of sulfur-cured butyl, according to the producer. The resin can be added to a compound either on a mill or in a Banbury mixer.

Better Cermets Needed for Gas Turbine Parts

A great deal of research has been done over the past 10 years to find a cermet with good impact resistance and good ductility for use in gas turbine engines operating at hot gas temperatures up to 2000 F. Recent work by P. T. Chiarito and J. R. Johnston of Lewis Research Center on titanium carbide stator blades shows that poor impact resistance and poor short-time ductility are still two of the biggest drawbacks associated with cermet turbine parts. (For more information on cermet turbine parts, see *Materials & Methods*, May '50, p 59 and May '57, p 270; also M/DE, June '57, p 204.)

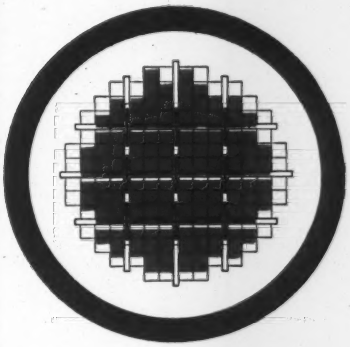
The two researchers believe that future research should be directed toward developing a better understanding of why cermets behave as they do. They say that such an understanding would probably lead to better cermets.

Higher temperature

The purpose of Chiarito's and Johnston's research was to determine the suitability of cermet turbine stator blades at an average turbine inlet gas temperature of 2000 F. This temperature is about

Correction

The thermal conductivity of silicon carbide foam listed in the table on p 136, line 12 of the July '59 issue is incorrect. The figures given (7 and 12) should be Ther Cond (800-1900 F), Btu/hr/sq ft/°F per *in.*, not per *ft* as indicated.



MATERIALS ENGINEERS

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Mr. P. W. Christos, Div. 40-MI, Aircraft Nuclear Propulsion Dept.

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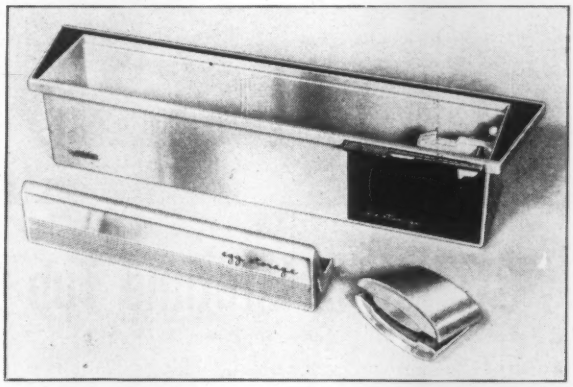

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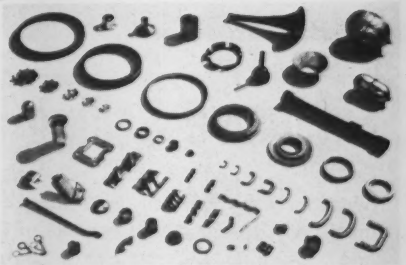

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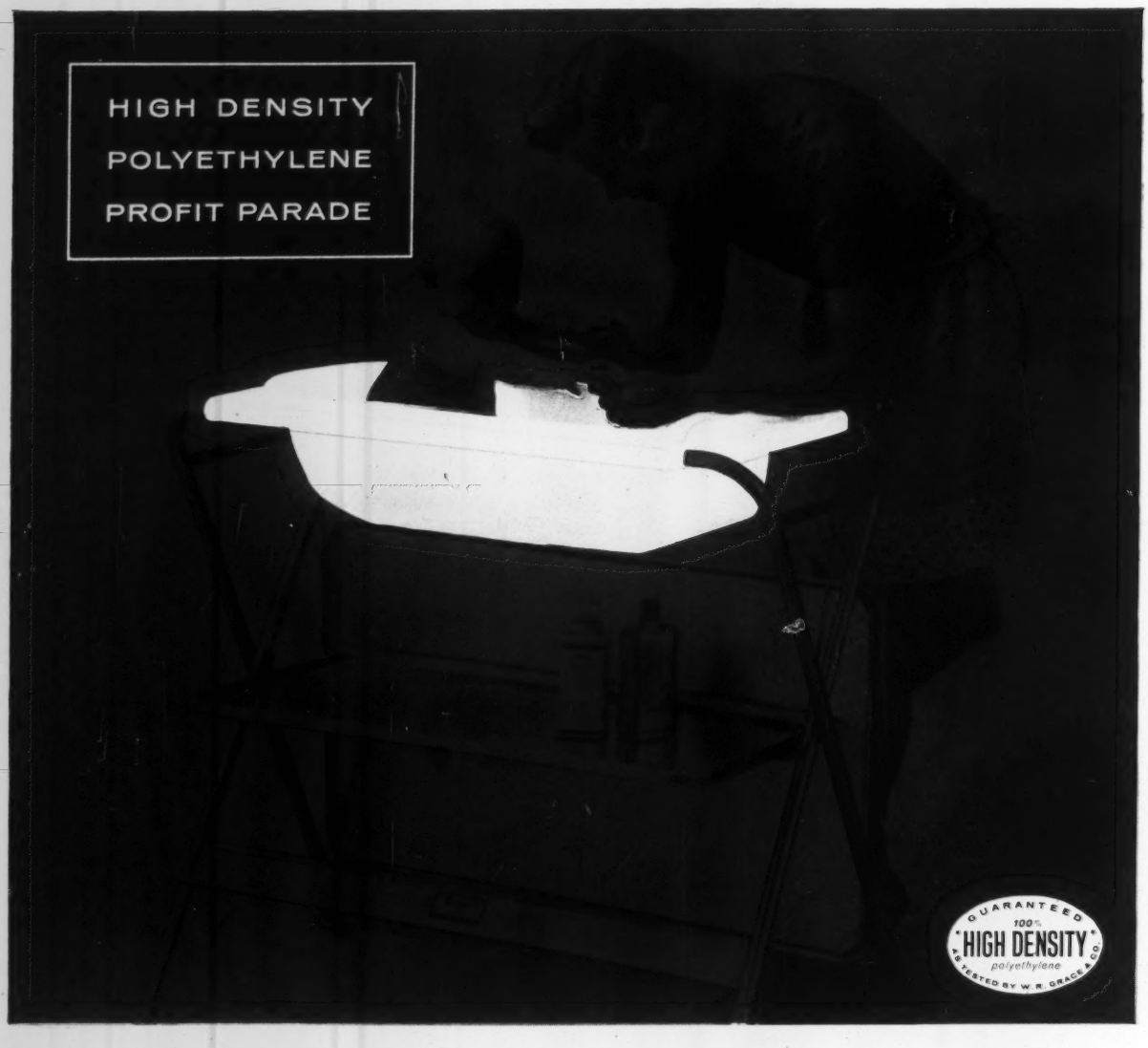

Exclusive Selling Advantages Offered in Lifetime Tub

Products in many different fields are gaining an edge over competition by utilizing the benefits of Grex high density polyethylene. The "Lifetime Tub" by Baby Bathinette Corporation is an example that really holds water.

This well-known manufacturer chose Grex to make a tub that would outlast competitive models since this is a tough plastic that is virtually indestructible. They used its molding characteristics to obtain a soft, pleasant, easy-to-clean texture. They took advantage of its strength and rigidity to make the tub light in weight for greater ease of carrying.

This new Grace plastic offers a unique combination of properties to help you create unique selling advantages. It takes a beating without chipping, cracking or breaking. It can be molded in any color and decorated. It resists the elements and most corrosive chemicals. And it is the only thermoplastic that takes boiling or freezing without losing its shape or strength.

If you need an idea of how to gain an edge over competition by using high density polyethylene be sure to call in the experts. Grace has the production facilities, technical service and experience to help put your product in the Grex profit parade. We're easy to do business with.

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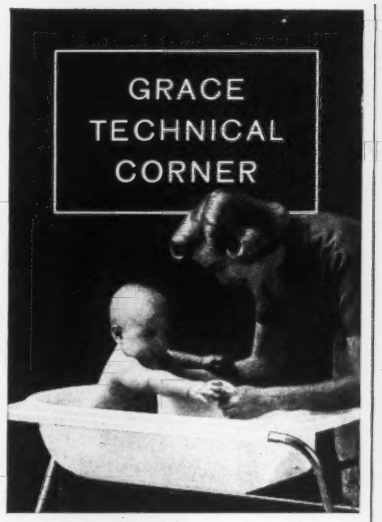

Grex answers design and molding problems on extra-large piece.

Don't let size limit your thinking when designing or molding with Grex high density polyethylene. The "Lifetime Tub" shown here is 30½" x 6½" x 19"—one of the largest pieces so far injection molded with this Grace plastic. Some of the technical thinking that went into this job may give you an idea of how to get the most from Grex.

Cost a design factor. Production of a piece as large as this tub invariably presents a cost problem. Taking advantage of the way Grex performs in thin wall sections, the designers were able to keep the amount of resin per tub to a minimum and permit economical cycle times. Use of thin walls, however, called for a design that would not only take care of the weight of baby and water but also provide for satisfactory suspension of the tub in its metal frame. Reverse curves solved both problems and minimized use of ribs and fillets to avoid heavy sections, sinks and depressions.

Mold surface. Depending on mold surface, Grex takes any finish ranging from high gloss to matte. In this case, it provided a smooth, pleasant texture—essential to protect baby and make cleaning easy—through the use of a highly polished chrome-plated mold.

Molding technique. Production of the tub involved a 3-pound shot of Grex, a large mold cavity and thin wall sections. Under these conditions, multigating was chosen over normal gating. With four gates the cavity was filled faster and strain reduced.

What are your problems? If you have a job in mind for high density polyethylene count on Grace for help. Now's the time to call, wire or write:

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What's new IN MATERIALS

400°F higher than temperatures normally encountered in turbojet engines. Tests were confined to a cermet (K162B) containing titanium carbide, nickel and molybdenum.

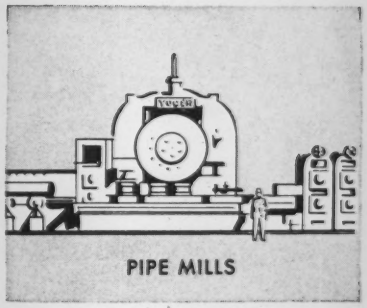
The cermet blades were first run in 100-hr endurance tests at normal gas temperatures (1540 F) in order to evaluate two methods for mounting the blades. The elevated gas temperature test was then run using the method of support considered best for high temperature operation. Cermet blades must be properly mounted in order to prevent restraints to loads that result from thermal distortions of the hot engine parts.

What study showed

The study showed that under carefully controlled operating conditions the life of cermet turbine stator blades would probably be acceptable

Branson Instruments, Inc.

Checking the bond of copper-steel laminates—Bridgeport Brass Co., Bridgeport, Conn. uses an ultrasonic resonance gage (shown above) to check the bond strength of copper-stainless steel laminated disks that are subsequently formed into kitchenware. Should there be any discontinuity in the bond, the disk may delaminate during drawing, or the defect may show up as a streak or blister in the finished product. To avoid this, an inspector marks a disk for special handling should the ultrasonic gage indicate a defect in the material.



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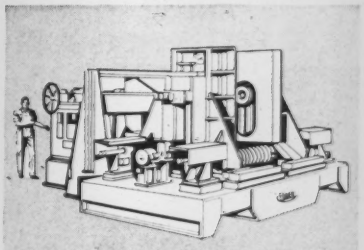

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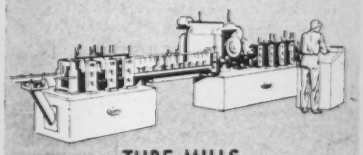

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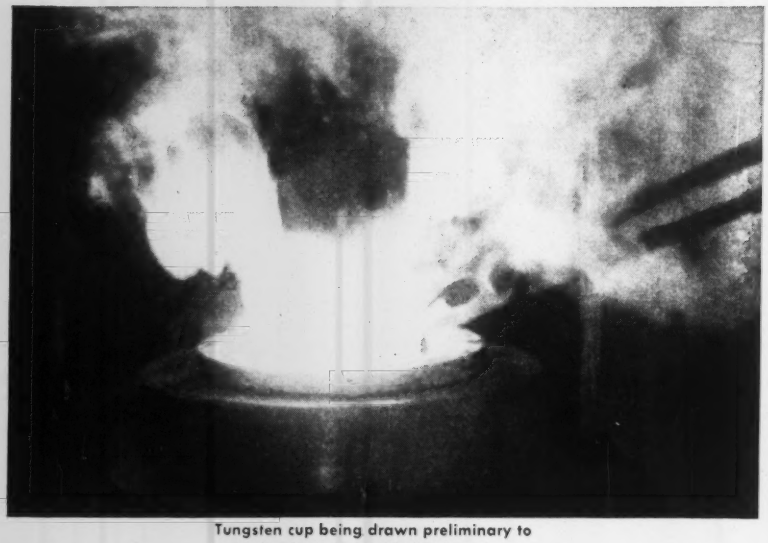
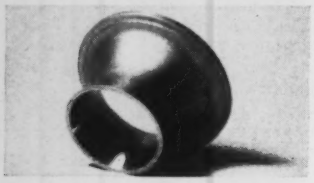


Tungsten cup being drawn preliminary to shaping into missile hardware.



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at temperatures that yield substantial increases in thrust (about 30% for a non-afterburning turbojet engine). The study also showed that:

1. Cermet blades mounted loosely in adjacent slots survived 52 hr at 2000 F with steady-state conditions prevailing throughout the test.
2. The trailing edges of the cermet blades were permanently distorted (the greatest distortion was in the hottest blade).
3. The cermet blades had considerable capacity for permanent deformation at a temperature of about 2300 F.
4. One of the cermet blades fractured. This blade was the only one that was tight in its support and was the only one exposed to relatively cool gas.
5. Oxidation occurred on the surface of the cermet blades. Although the oxide coating was impervious and adherent, it did not protect the blades against extreme corrosion at 2000 F.

Details of the study on cermet stator blades may be found in *Memo 2-13-59E*, available from National Aeronautics and Space Administration, Washington, D. C.

Metallized Coatings Resist Salt Air, Spray

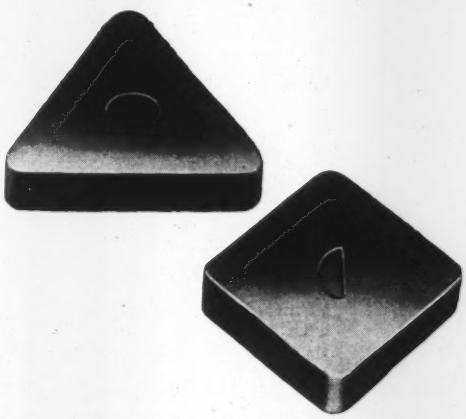
Aluminum and zinc metallized coatings protect steel after three years exposure in rural, industrial, salt air and salt spray environments, according to a recent report issued by the American Welding Society.

This is the first report of an AWS evaluation program in which aluminum and zinc metallized specimens are to be reexamined at 6, 9 and 12-year intervals. Over 4300 specimens are exposed at eight test sites throughout the United States.

How coatings performed

The AWS report shows that vinyl-sealed aluminum coatings afforded better protection than vinyl and chlorinated rubber-sealed zinc coatings. Sealed aluminum coatings held up well in atmospheric and salt spray environments, whereas zinc coatings showed some localized dissipation of the vinyl seal coat in atmospheric

165 CARMET INDEXABLE SQUARE CARBIDE INSERTS WOULD COVER THIS PAGE



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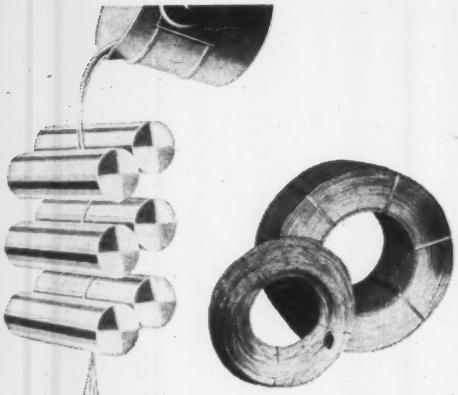

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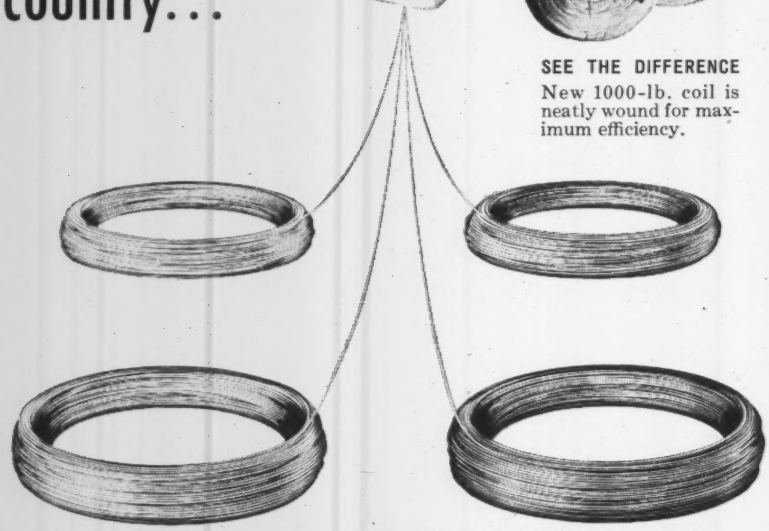

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A special method of continuous casting eliminates the porosity of wire cast in water-cooled molds . . . brings you weld-free wire in coils up to 1000 lbs.

SPEED. With this new large coil your production runs are longer than ever before. Riverside wire speeds and smooths your fabrication and scheduling.

QUALITY. Riverside *continuous-cast* material is denser, more homogeneous than antiquated mold-cast products. Wire drawn from the continuous coil is stronger, free from weak spots which can stop production and cause high reject rates.

Your production equipment can be easily adapted to hold the new 1000-lb. coils of Riverside continuous-cast bronze wire. Find out how you can save with this remarkable new process. Write *Riverside-Alloy Metal Division, H. K. Porter Company, Inc., Riverside, N. J.*

RIVERSIDE-ALLOY PORTER **METAL DIVISION**

H.K. PORTER COMPANY, INC.

PORTER SERVES INDUSTRY: with Rubber and Friction Products—THERMOID DIVISION; Electrical Equipment—DELTA-STAR ELECTRIC DIVISION, NATIONAL ELECTRIC DIVISION; Copper and Alloys—RIVERSIDE-ALLOY METAL DIVISION; Refractories—REFRACTORIES DIVISION; Electric Furnace Steel—CONNORS STEEL DIVISION, VULCAN-KIDD STEEL DIVISION; Fabricated Products—DISSTON DIVISION, FORGE AND FITTINGS DIVISION, LESCHEN WIRE ROPE DIVISION, MOULDINGS DIVISION, H. K. PORTER COMPANY de MEXICO, S. A.; and in Canada, Refractories, "Disston" Tools, "Federal" Wires and Cables, "Nepcoduct" Systems—H. K. PORTER COMPANY (CANADA) LTD.

For more information, turn to Reader Service card, circle No. 465

What's new IN MATERIALS

environments.

In sea water, sealed and unsealed zinc metallized coatings corroded rapidly. In many spots on the steel specimen the zinc coating had dissolved and had been replaced by a fairly adherent zinc corrosion product. This corrosion product is protective, and no rusting of the base metal occurred except for a few small spots in specimens coated with 0.006 in. of zinc.

The three-year interim report of corrosion tests on metallized coatings (No. C. 2.7-59) may be obtained from the American Welding Society, 33 W. 39th St., New York 18, at a price of 50¢.

Other News . . .

Metals

▸ A resilient, welded, stainless steel honeycomb core is said to have good resistance to damage during normal production operations. The honeycomb core, identified as Condition C, was developed by Hexcel Products Inc., 2332 4th St., Berkeley 10, Calif.

▸ General purpose seamless aluminum tube is now available from Chase Brass & Copper Co., Waterbury 20, Conn. The tube is made from 3003-O aluminum alloy in soft temper. Sizes range from ⅛-in. o.d. by 0.025-in. wall to ¾-in. o.d. by 0.049-in. wall.

▸ Chicago Development Corp., 5810 47th Ave., Riverdale, Md. is offering trial quantities of a new vanadium additive for titanium alloys. The additive, called CDC VAN-AD, is particularly recommended for use in titanium consumable electrodes. The additive sells for $35 per lb.

▸ An aluminum alloy, called Alcan tube alloy, has been developed especially for extrusion into round, square, triangular and octagonal furniture tubing. Up to now only round furniture tubing could be extruded from aluminum. The alloy is available from Aluminium Ltd. Sales, Inc., 630 5th Ave., New York 20.

▸ A lightweight, high strength, extruded aluminum grating for scaffolding, balconies and catwalks has been introduced by Read Standard Div., Capitol Products Corp., York, Pa. The grating is assembled by a

Wallex Casting on Tail Skid Protects Navy Jet Fighter

When navy jets land on pitching ships, jet tails sometimes hit and scrape the deck. To protect both the aircraft and the deck, McDonnell puts smooth pads on the tail skids of its Demon jet fighter. Cast of wear-resistant Wallex alloy, these pads rebuff impact and corrosion, create little friction to mar flight decks.

Curved Wallex casting brazed to steel plate forms tail skid pad assembly.

As our example above shows, the proper functioning of a whole assembly can often be insured by protecting just one small area from damaging wear. Castings of various Colmonoy alloys are doing just that, in hundreds of places. Colmonoy nickel, cobalt, and iron-base alloys are also applied as welding rod, electrodes, paste, and as Sprayweld Powder. Learn more about this remarkable group of alloys.

Ask for Colmonoy Hard-Facing Manual No. 79.

HARD-SURFACING AND BRAZING ALLOYS

WALL COLMONOY
CORPORATION
19345 John R Street • Detroit 3, Michigan

BIRMINGHAM · BUFFALO · CHICAGO · HOUSTON · LOS ANGELES
MORRISVILLE, PA. · NEW YORK · PITTSBURGH · MONTREAL · GREAT BRITAIN

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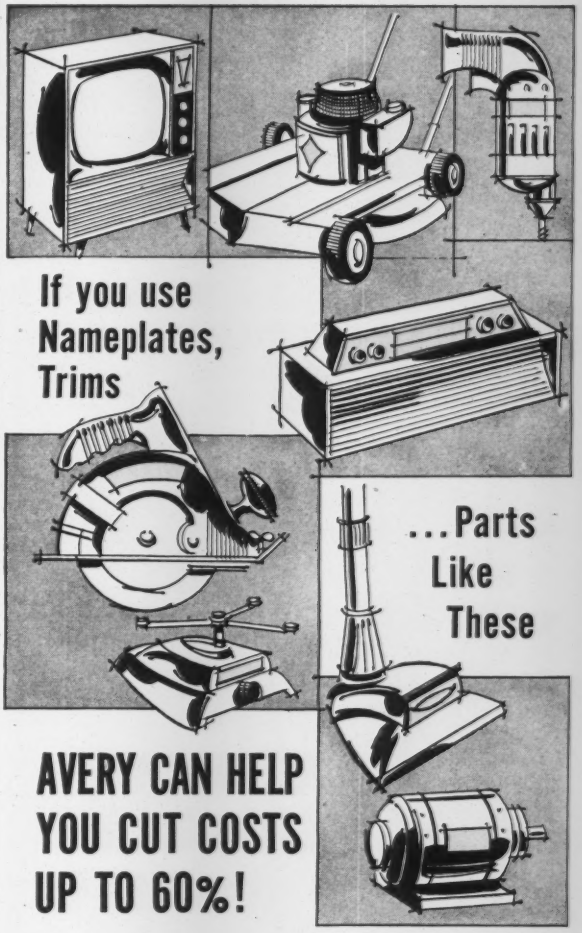


AVERY CAN HELP YOU CUT COSTS UP TO 60%!

Avery pressure-sensitive nameplates, trims, panels and labels cut costs three ways — in labor, in materials and in tools!

You save labor because Avery pressure-sensitive components are easier, less time consuming to apply. All that is required is to remove the backing paper and press in place.

You save more on materials and tools because none are needed — no drills, special tools or fasteners of any kind!

What's more, Avery nameplates and trims are exceptionally attractive . . . add an air of "quality" to every product. Available in a variety of new metallics — mylar, foil, and vinyls.

Investigate the opportunities Avery pressure-sensitives offer you to simplify assembly, cut costs and improve product appearance! You'll find — as have many other leading manufacturers — savings up to 60% in labor, tools and material easy to achieve . . . a better looking product a natural result!

A Avery Label Company

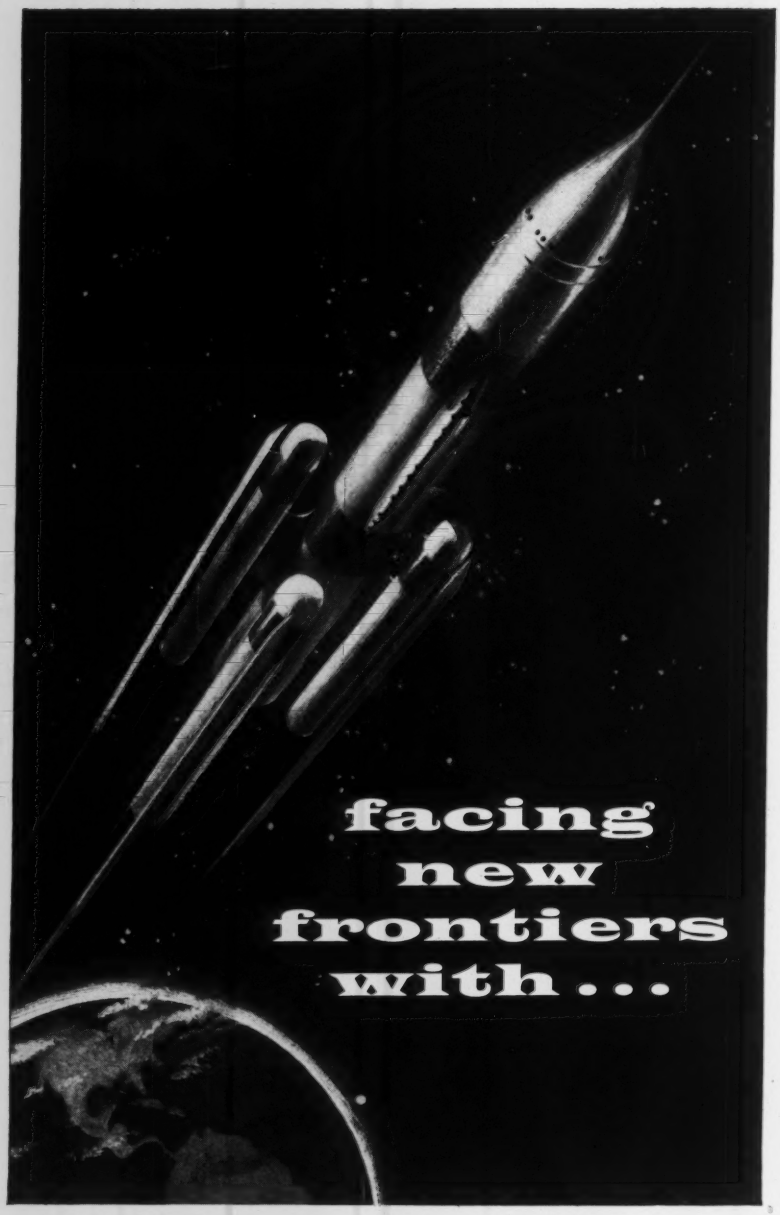
Decorative Products Department

2123 E. 9th Street, Cleveland 15, Ohio • 117 Liberty Street, New York 17, New York
1616 So. California Avenue, Monrovia, Calif.

Dept. M9, Avery Label Company, Decorative Products Department
2123 E. 9th Street, Cleveland 15, Ohio
Please rush samples and free brochure to me at once.

Name _____
Title _____
Company _____
Address _____
City _____ Zone ___ State _____

For more information, turn to Reader Service card, circle No. 467



BERYLLIUM

There are many good reasons why beryllium is increasingly used by aircraft and missile-makers.

• light weight • high modulus
• high temperature strength • excellent thermal conductivity

Today, beryllium parts are being designed by missile and aircraft manufacturers into *current* programs. This is one of the metal's growing new frontier areas.

A free illustrated brochure on Berylco HPA beryllium is available. Write to—

BERYLCO® **THE BERYLLIUM CORPORATION**
P. O. Box 1462, Reading, Pennsylvania

For more information, turn to Reader Service card, circle No. 524

special "snap-lock" fastening method rather than by welding.

▸ Off-center copper tube for use in electrical and induction heating applications is available from Phelps Dodge Copper Products Corp., ACP Div., 300 Park Ave., New York 22. The tube, offered in square and rectangular sizes up to 3 in. in dia, is supplied in electrolytic and oxygen-free copper.

Plastics and rubber

▸ Samples of isophthalic polyester and alkyd resins are now available for evaluation and testing from Oronite Chemical Co., 200 Bush St., San Francisco 20. Isophthalic polyester resins, discussed in a previous issue of this magazine (see M/DE, Apr '59, p 134), are said to have high flexural strength at elevated temperatures and good creep resistance when wet.

▸ Celanese Corp. of America, Plastics Div., 180 Madison Ave., New York 16 has added a flame resistant resin to its Fortiflex A series of linear polyolefin resins. The new material is available in melt indexes of 0.7, 2.5 and 5.0. It sells for 48¢ per lb in carload quantities.

▸ Waste foam rubber and polyurethane scraps can be turned into new sheets or molded foam rubber articles by using a new liquid rubber called Rubtex. The liquid polymer will bond both similar and mixed scrap, whether derived from natural or synthetic rubber, as well as scrap vinyl foam. The liquid polymer is available from Rubba, Inc., 1015 E. 173rd St., New York City.

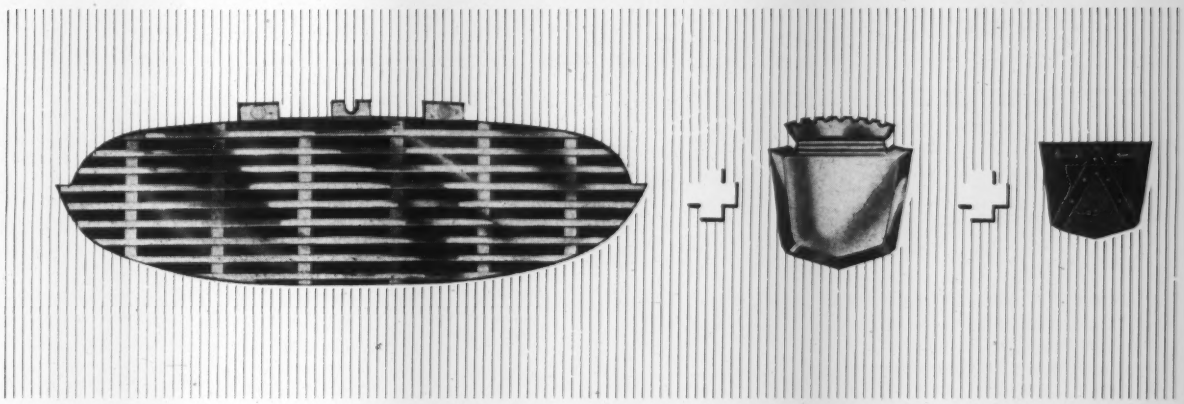
Other nonmetallics

▸ A "production line" grease has been developed which lubricates at temperatures above 1000 F. The grease, designated Hi-Temp 2409, is composed of an organic thickener, a synthetic carrying agent, and a solid lubricant (fine particle graphite) which forms a soft graphite film on bearing surfaces. The grease is available from E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33.

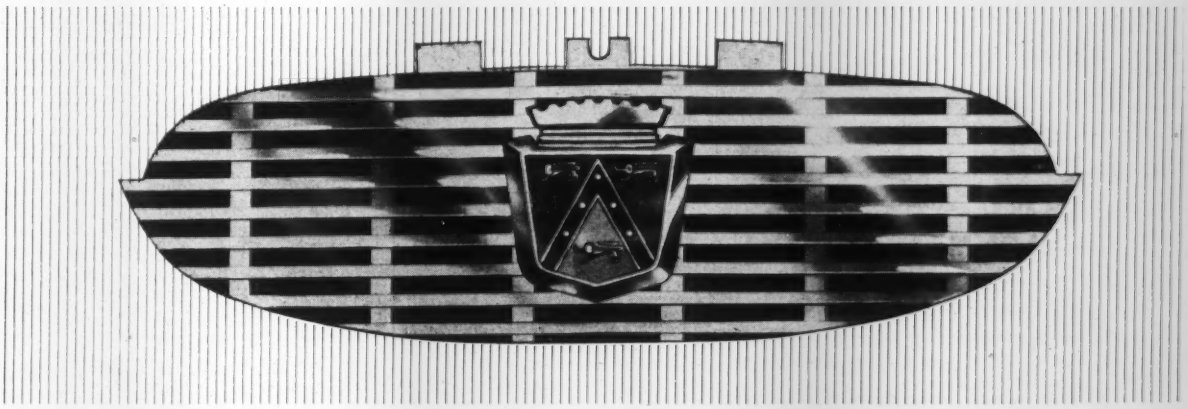
▸ H. K. Porter Co., Refractories Div., Porter Bldg., Pittsburgh 19 has introduced a chemically bonded, high alumina refractory brick for use in aluminum melting furnaces. The brick is called Multex-85.

▸ Spiral - wound, inorganic - bonded mica paper tubes and coil forms retain a dielectric strength of 80 v per mil and a volume resistivity of

Cost of 3-part metal-plastic medallion cut **57%**



by switching to this 1-piece PLEXIGLAS molding



Proof that you can save with **Plexiglas**

Everybody recognizes the economics of using a single molded plastic part rather than a multi-part assembly. But when you mold the complete unit of PLEXIGLAS® acrylic plastic, the *saving* is just one of many outstanding advantages you gain.

Obviously, assembly time is eliminated. There are no metals to corrode, tarnish or pit. All decorative effects are protected from harm on the underside of the molding. The surface is mirror smooth and continuous. Color range, metallic effects and accurate reproductions of trademarks are almost unlimited. And there's built-in resistance to breakage and weathering.

The above example is based on estimated costs . . . and incidentally, saved this company thousands of dollars.

Perhaps you can put PLEXIGLAS to work for your company . . . at a big saving. Write for information and molding help.

In Canada: *Rohm & Haas Co. of Canada, Ltd., West Hill, Ontario.*

Chemicals for Industry

ROHM & HAAS COMPANY

WASHINGTON SQUARE, PHILADELPHIA 5, PA.

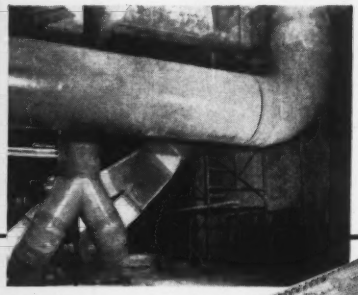
For more information, turn to Reader Service card, circle No. 439

corrosion resistant **DURACOR**

replaces costly metal fabrications

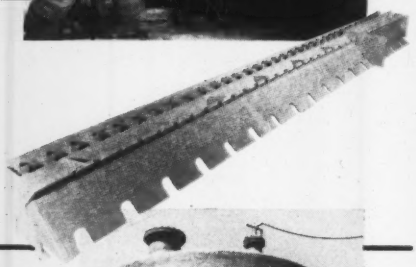
in the
METALWORKING
industry

Ceilcote engineers complete ventilating systems, gas scrubbing towers, hoods, tank covers, ducts, recovery tanks and other customized fabrications.



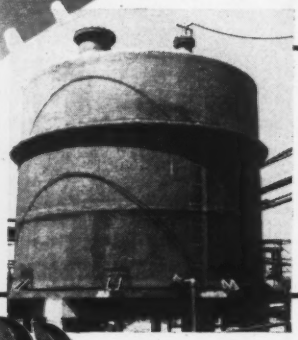
in the
TEXTILE
industry

Complex rayon spin machines, feed pipes, filters, screens, tanks and similar equipment are fabricated from Duracor.



in the
PETROLEUM
industry

Acid storage tanks, tank trailers, exhaust systems, pressure pipes and other Duracor products are rendering outstanding service.



in the
CHEMICAL
industry

Duracor is used extensively for special processing equipment, processing tanks, laboratory sinks, brine tanks, acid storage tanks, covers and ventilating systems.

PHYSICAL PROPERTIES

Tensile Strength p.s.i.: 11,000-15,000

Flexural Strength p.s.i.: 20,000-30,000

Tensile Modulus of Elasticity p.s.i.: 1.2—1.4 x 10^6

Flexural Modulus of Elasticity p.s.i.: 0.78—1.6 x 10^6

Impact Izod, Notched ft.-lbs./in.: 30—40

Specific Gravity: 1.4

Coefficient of Linear Expansion: 9.5 x 10^{-6} in./in./°F.

Standard Color: Light Green/Gray

Maximum Temperature (Exposure): To 500°F.

Save up to 40% over costly metal structures with Duracor processing equipment and ventilating systems! A product of Ceilcote's 33 years of corrosionproofing experience, Duracor combines extreme chemical resistance and high strength with light weight, heat and flame resistance. WRITE TODAY FOR VISUAL STANDARDS AND INDUSTRY SPECIFICATIONS!

THE CEILCOTE COMPANY, inc.
4899 Ridge Road • Cleveland 9, Ohio

DURACOR CEILCOTE

8595-CC

For more information, turn to Reader Service card, circle No. 536

What's new IN MATERIALS

3.4 x 10^9 ohm-cm after aging 1000 hr at 1100 F. The parts, called Pyrotherm, are available from Resinite Corp., Div. of Precision Paper Tube Co., 2035 W. Charleston St., Chicago 44.

▸ A silicone-treated woven pile weather seal for automotive, aircraft and marine applications is available from Schlegel Mfg. Co., 1555 Jefferson Rd., Rochester, N. Y. The weather seal or channel can be flexed to 45 deg without binding or kinking.

▸ A radiation resistant, high temperature ceramic wire insulation has been developed by Technical Industries Corp., 389 N. Fair Oaks Ave., Pasadena, Calif. The material is called Durock. Its composition has not been revealed.

Finishes

▸ Automotive finishes made with a new short-oil, nondrying alkyd resin are said to retain their original color and gloss for a number of years after application. Enamels formulated with the resin are said to have excellent hot hardness and good resistance to marring and scratching. The resin, called Aroplaz 2580-X-60, was developed by Archer-Daniels-Midland Co., 700 Investors Bldg., Minneapolis 2, Minn.

▸ A fine-particle polyvinyl acetate homopolymer emulsion is said to have excellent mechanical stability, good blocking resistance and good freeze-thaw stability. The emulsion, called Gelva TS-85, is suggested for use in paper coatings, textile finishes and surface coatings. It is available from Shawinigan Resins Corp., Dept. SN, Springfield 1, Mass.

▸ An acidic detergent that is said to have good cleaning, smut-removing and prepaint conditioning properties has been introduced by Oakite Products, Inc., 132H Rector St., New York 6. The product, called No. 86, can be used on steel, brass, aluminum, zinc and terne plate.

▸ A moisture-absorbing rust preventive is now available from Rust-Lick, Inc., 755 Boylston St., Boston 16. The material, called Rust-Lick 606, is supplied in a special dispenser.

▸ Permanently embossed labels for identifying patterns, molds, valves, controls and other equipment can be made with a new hand embossing machine developed by Dymo Corp., 2546 10th St., Berkeley 10, Calif. Labels can be made on plastics or

Introducing the finest in engineering and maintenance steels . . .

Reduce maintenance problems on spindles, arbors, shafts, bolts, etc.

High Strength VISCOUNT 44

NOMINAL ANALYSIS

Carbon	.40	Chromium	5.00
Silicon	1.00	Molybdenum	1.20
Manganese	.75	Vanadium	1.00

plus Alloy Sulphides

TYPICAL MECHANICAL PROPERTIES

Furnished Hardness	RC 42-46
Ultimate Strength, psi	200,000
Yield Strength (0.2% offset) psi	175,000
Reduction of area, %	42
Elongation, 2" —%	12
Coefficient of Expansion 80-1000°F	7.0×10^{-6}

More and more machine tool components and maintenance parts are being made of Latrobe's prehardened VISCOUNT 44. Why? Because this steel is easy to machine—has unexcelled strength, good toughness and exceptional wearing qualities. Suitable for parts operating up to temperatures of 1000°F. Prehardened, Viscount 44 eliminates risk of size change and distortion resulting from heat treatment.

Used for spindles, arbors, shafts, axles, brake dies, bolts, forming rolls, and other machine tool parts, Viscount 44 achieves outstanding performance. Its added strength and increased wear resistance surpasses that normally resulting from the use of other existing engineering and maintenance steels.

Have a maintenance steel problem? Call a Latrobe Sales Engineer for help in selecting the *best* steel for the job!

For literature describing VISCOUNT 44, contact . . .

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Metalmasters
for Industry

LATROBE STEEL COMPANY

LATROBE, PENNSYLVANIA

BRANCH OFFICES AND WAREHOUSES:

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SAN LEANDRO • TOLEDO

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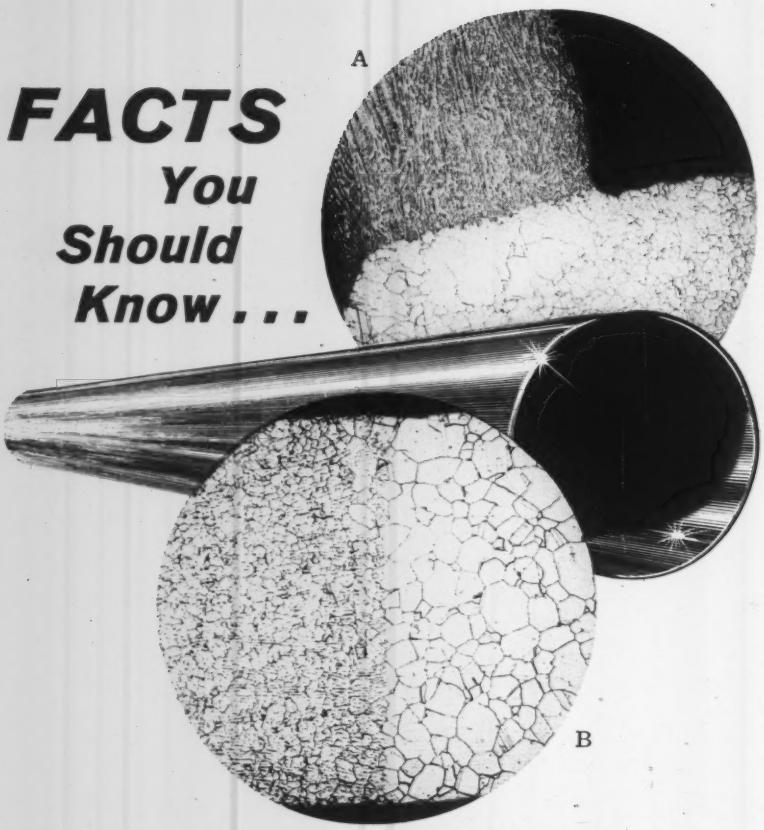
FACTS You Should Know . . .



about the DIFFERENCE in Stainless Steel Tubing — —

Both photographs above show the microstructure of the weld and base metal of Type 304 stainless steel tubes. Photograph A reveals accelerated corrosion of the weld metal due to the presence of delta-ferrite. This tube was manufactured by welding, swaging and annealing, which is an insufficient amount of cold work to produce a high quality, uniformly corrosion-resistant welded tube.

Photograph B shows a typical tube supplied by Wallingford Steel. This tube was produced by the welding and cold drawing process, then inspected with a Magne Gauge to insure no ferrite was present in the weld metal. *Processed and inspected in this manner, Wallingford Cold Drawn Tube is guaranteed to show no preferential attack in weld area.*

All Wallingford welded stainless steel tubing is cold drawn and inspected by Magne Gauge. *Can your suppliers say this about the stainless steel tubing they produce?* Wallingford's manufacturing techniques and quality control checks assure top quality — *yet cost you no more.* Why not purchase *your* tubing where *tonnage is produced on a laboratory basis?*

THE WALLINGFORD STEEL CO.

Progress in Metals for over 37 Years

WALLINGFORD, CONN., U.S.A.

COLD ROLLED STRIP: *Super Metals, Stainless, Alloy*
WELDED TUBES AND PIPE: *Super Metals, Stainless, Alloy*

For more information, turn to Reader Service card, circle No. 384

What's new IN MATERIALS

metal tapes supplied by the company. The labeling machine sells for $34.95.

▸ A spray coating, composition of which has not been revealed, has been developed by Maas & Waldstein Co., Inc., McCarter Hwy., Newark, N. J. for simulating brass, gold, copper, bronze and other finishes over bright nickel plate. The coating is called Platelustre.

Joining materials

▸ A flux, called Wonderflux No. 4, has been developed for induction and other short cycle brazing operations. The flux melts at 480 F and is water-thin at 800 F. It is available from American Silver Co., 36-07 Prince St., Flushing 54, N. Y.

▸ Porous-free plastics rod for welding polyvinyl chloride and other plastics parts is now available from Laramy Products Co., Box 8, Hingham, Mass. The rod is said to produce uniform welds. It is supplied in diameters of 1/8, 5/32 and 3/16 in.

▸ Curtisol is a new and economical solder developed for soldering titanium and titanium-base alloys at low temperatures. It is used in conjunction with Curtiflux, a special fluxing agent compounded for use with low temperature silver solders. Both the solder and the flux are available from Curtiss-Wright Corp., Princeton Div., Princeton, N. J.

▸ An aluminum welding wire, designated A5556, has been developed for use in welding high tensile aluminum alloys such as 5083, 5086 and 5486. The wire is available from Air Reduction Sales Co., Div. of Air Reduction Co., Inc., 150 E. 42nd St., New York 17.

▸ A reusable lock nut with a precisely engineered number of locking teeth has been developed by MacLean-Fogg Lock Nut Co., 5535 N. Wolcott Ave., Chicago 40. According to the producer, the number of teeth on each nut size is varied so that the stress per tooth does not vary measurably from one size to the next.

Testing equipment

▸ A power-operated, remote-controlled impact tester meets the requirements of ASTM Method E-23, and performs Izod, Charpy and tension-impact tests on metals. The machine is marketed by Testing Machines, Inc., 72 Jericho Turnpike, Mineola, N. Y.

(cont'd from p 16)

field. Making tests under shop conditions with these costly and often experimental alloys would not be practical.

From observing test samples of various widths and from practical shop observations, I disagree with the theory that length has an effect on bend cracking. For a "straight line" bend the action is the same except at the extreme ends. If a curvature is introduced into the bend, the results are naturally different. The tests outlined in the article did not claim to predict specific results.

Grain direction tables were set up so that where an absolute minimum bend is required, a selected piece can be used. If high production runs or liberal tolerances are to be used then it is simple to use the overall minimum radius plus an adequate safety factor.

In regard to the Olsen test, I want to point out again that my article did not pretend to predict absolute values. The Olsen test is a quick and relatively inexpensive method of accurately determining *relative* formability for various materials.

When a product requires designing close to material limits, it is most efficient to run laboratory tests to establish basic data and then use practical shop "know-how" to deviate when required by a practical consideration. Even where tolerances are liberal, a basic test program is helpful.

D. A. STEWART, Supervisor
Metal Working Laboratory
Aircraft Gas Turbine Div.
General Electric Co.
Cincinnati, Ohio

Thermal conductivity of monel

To the Editor:

This refers to my article "Graphite—How It Compares with Metals, Ceramics," which was published in the June '59 issue of *M/DE*. A reader has written to me to point out an error in the graph on p 90. There is a decimal point error in the value of the thermal conductivity of monel. It should be 0.062, not 0.62.

G. B. ENGLE
Speer Carbon Co.
Niagara Falls, N. Y.

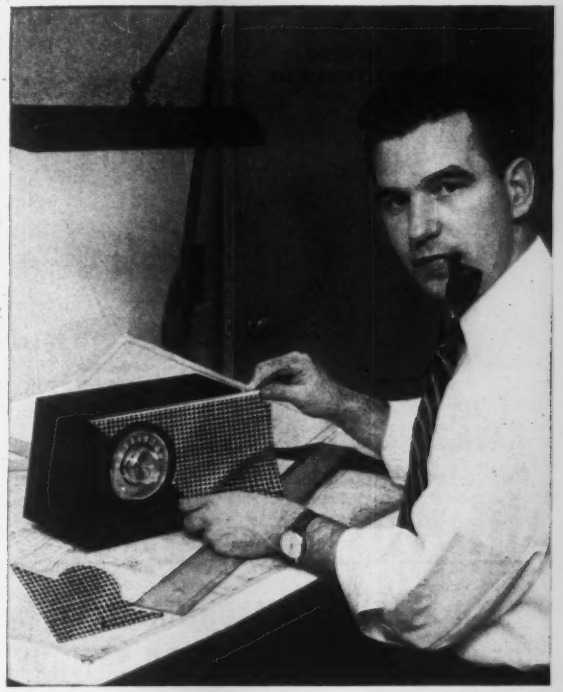
SAMPE

To the Editor:

It was a pleasure to see your editorial on the Society of Aircraft Materials and Process Engineers in the July issue of *M/DE*. Thank you very much for explaining and endorsing the Society.

We of the Midwest Chapter read the editorial with delight. Naturally, after working so hard to organize and start the organization, we are most appreciative of the complimentary comments coming from such a highly recognized magazine.

JOSEPH BAYER
President
Midwest SAMPE



Fasson Self-Adhesives Offer You
5 Practical Advantages!

1 **EASIER TO APPLY—Saves Labor!**
Requires no special skills! Simply remove the backing paper and press into place.

2 **NO SPECIAL TOOLS OR EQUIPMENT—Saves Investment!**
Fasson materials apply quickly, easily! Adhesion is instant. No slippage, cleaning up!

3 **ELIMINATE COSTLY STEPS IN PRODUCTION—More Profit!**
No drilling, tapping, fasteners or glue pots required. Speeds assembly, cuts costs!

4 **WIDE RANGE OF MATERIALS—One Reliable Source!**
Available in Mylar* laminates, foils, vinyls, polyesters, acetates and papers.

5 **SUPERIOR QUALITY—Look Better, Last Longer!**
Manufactured under the most careful quality control insuring the highest standards and uniform quality.

** Mylar is a DuPont Polyester Film.*

It will pay you to investigate Fasson self-adhesive materials . . . They're ideal for all kinds of nameplates, emblems, kickplates, decorative trims, panels, instruction labels, diagrams . . . to mention a few. The materials can be die cut in any shape or size . . . embossed, hot stamped, or printed with conventional equipment.

Write Today for Free Samples and Descriptive Brochure.
Send requests to Dept. T-9

fasson | **Fasson Products**

A Division of Avery Adhesive Products, Inc.
ELmwood 2-4444 • 250 Chester Street • Painesville, Ohio

For more information, turn to Reader Service Card, circle No. 459

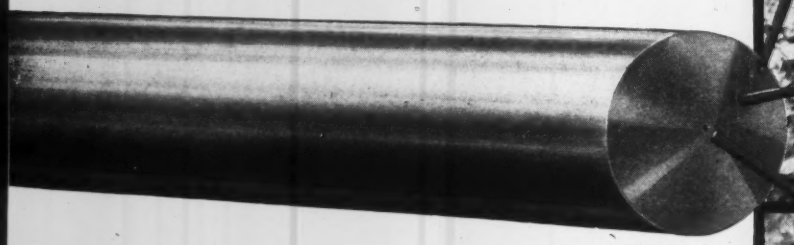
La Salle fatigue-proof STEEL BARS

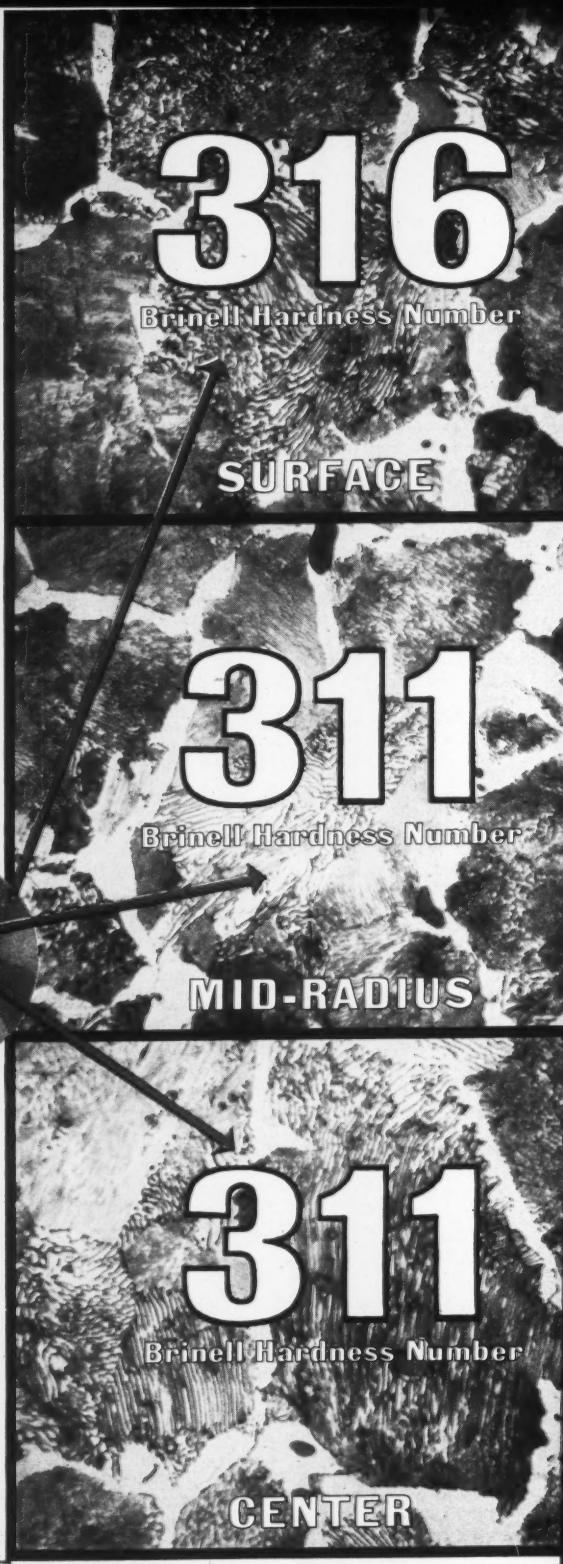
MADE BY e.t.d. PROCESS
Elevated Temperature Drawing

HAVE A UNIQUE COMBINATION OF

uniform properties

HIGH STRENGTH, MACHINABILITY, RESISTANCE TO WEAR AND FATIGUE, DIMENSIONAL STABILITY





The microscope shows the uniformity of FATIGUE-PROOF. Its uniformly pearlitic structure parallels its uniformity of properties from the surface to the center of the bar.

FATIGUE-PROOF strength and hardness are developed by "e.t.d." (Elevated Temperature Drawing). Unlike quenching and tempering, its effect is the same from surface to the center of the bar. It works a large bar as uniformly as it does a small bar.

There is no mass effect.

The microscope proves it. Surface, center, or mid-radius, FATIGUE-PROOF is pearlitic. There are no mixtures of bainite, martensite, and pearlite. FATIGUE-PROOF is uniform bar to bar, size to size, and lot to lot.

T. M.—Trade-marks of La Salle Steel Company

1⅞" round FATIGUE-PROOF. Magnification: 750X

JUST PUBLISHED—Request your copy of 24-page brochure, "A new material" . . . it tells the complete story of FATIGUE-PROOF.

Name_____

Company_____

Address_____

City_____ Zone____ State_____

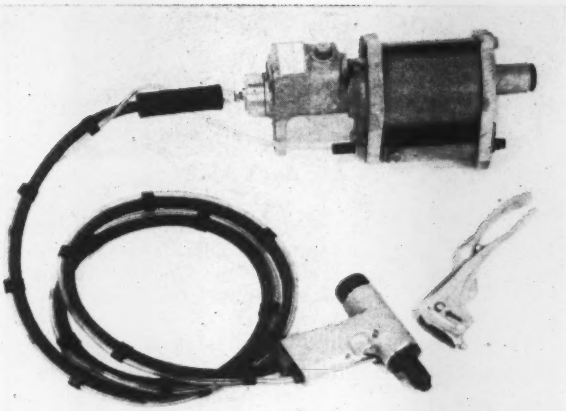
Mail to La Salle Steel Co., 1418 150th St., Hammond, Ind.

For more information, turn to Reader Service card, circle No. 455

La Salle STEEL CO.

1418 150th Street • Hammond, Indiana

Manufacturers of America's Most Complete Line of Quality Cold-Finished Steel Bars



Riveting tools *are lightweight, inexpensive.*

AT WORK

Riveting—
cont'd from p 12

is sufficient and no accessory equipment is required.

3. *High production rate*—Although many factors determine production rate (number of assembly operations, type of material, etc.), riveting rates of several hundred per hour are common, and rates can go as high as 1000 per hour.

4. *Dissimilar materials can be joined*—In addition to joining plastics to plastics, the method can join plastics to metal, porcelain, wood or leather.

5. *Tools are lightweight* — Both manual and power tools are portable (see photo) and are as easy to use for overhead and vertical work as for horizontal work. For large or awkward products such as appliances, automobiles, boats, etc., the tools can be brought to the work rather than the other way around.

6. *Blind riveting is possible*—Ducts, tubes, hollow shapes, etc. can be joined to other sections despite the fact that the internal area is inaccessible. The rivet is simply inserted into mating holes and the mandrel pulled from the accessible side (see sketch).

Applications

The riveting technique can be used for any of the plastics materials, whether molded, extruded or laminated.

Typical applications are attaching metal trim to plastics moldings (see photo), molded escutcheons to metallic parts, wall panels to metallic frames, plastics tubing and ducts, refrigerator liners, decorative trim, decks to hulls of small reinforced plastics boats (see photo), and control knobs and insulators in electronic equipment.

Wire Tire Resists 2000 F

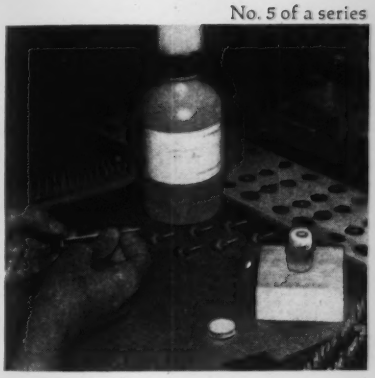
Heat *does not harm wire tire.*

What appears in the photo at the left to be a wire burnishing wheel is actually a wire wheel and tire designed to solve landing problems of future rocket-powered aircraft.

The tire, which contains no rubber or fabric and does not have to be inflated, will withstand temperatures in the 1000-2000 F range in flight and during landings. It is designed for use as a landing wheel and tire for vehicles that pass through the thermal barrier during re-entry from outer space.

According to Goodyear Tire & Rubber Co., simulated tests indicate that the new tire has load-deflection characteristics similar to those of pneumatic tires. However, it has a

No. 5 of a series



Eastman 910 Adhesive solves another production bottleneck

Electro-Voice, Inc., of Buchanan, Michigan, manufactures miniaturized phonograph cartridges, called "Power-Point," for high-fidelity audio systems.

The cartridge consists of a jewel-tipped ceramic transducer in a plastic boot, encased in nylon. Assembly is handled on a conveyorized production line and depends on rapid bonding of the components to obtain economical high-volume output.

The critical bonding problem is solved with Eastman 910 Adhesive.

Immediately following hand assembly, a drop of the adhesive is applied to the tiny components. *Moments later, a permanent bond is formed*...and the unit moves on, without delay.

Eastman 910 Adhesive is making possible faster, more economical assembly-line operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

Eastman 910 Adhesive is simple to use. No mixing, heat or pressure is required. Upon spreading into a thin film between two surfaces, setting begins immediately. With most materials, strong bonds are made in minutes.

What production or design problem can this unique adhesive solve for you?

Bonds Almost Instantly ...Without Heat, Pressure or Catalyst

For a trial quantity (⅓-ounce) send five dollars to Armstrong Cork Company, Industrial Adhesives Division, 9109 Dunbar Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Division, Dept. E-9, Kingsport, Tenn.

For more information, circle No. 462

MET-L-WOOD

METAL BONDED TO PLYWOOD

DUCT and RISER ENCLOSURES

...faster, cleaner installation

...lasting finished beauty

...complete accessibility

Installing Met-L-Wood riser enclosures, air ducts, convector covers and paneling benefits everyone connected with the job:

Architects and contractors plan on substantial installation time savings and know that smooth, uniform Met-L-Wood needs only paint to finish after installation.

Building management not only gets a clean, durable installation, fast; but is also assured of low-cost accessibility to pipes and other equipment without enclosure replacement expense.

Met-L-Wood units are pre-formed, ready to install with minimum labor. When finished, Met-L-Wood sections match perfectly with conventional walls and ceilings.

Whether you plan new construction or remodeling, write for literature now and learn all the advantages and economies you gain with Met-L-Wood.

MET-L-WOOD® CORPORATION

6755 W. 65th Street
Chicago 38, Illinois

For more information, turn to Reader Service card, circle No. 460

higher rolling resistance and thus provides an advantage in braking and slowing the aircraft. And, it is blow-out proof, of course.

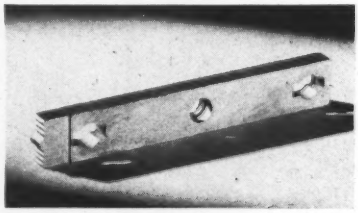
Weight of the wheel and tire, which measures 14 in. in dia and 4 in. wide, is about 40 lb.

Winning Designs in Powder Metallurgy

Shown in the accompanying three photos are the winning entries in New Jersey Zinc Co.'s recent Awards Competition for the best use of brass or nickel silver powder metallurgy in the design or redesign of an industrial or consumer product.

The following four factors were considered most important: 1) orig-

Shaped charge liner—*Brass powder design replaced drawn copper because controlled particle size and density of the part allows complete frangibility for penetration of an oil well liner without the clogging effect of solid metal particles.* —Jet Research Center



Proportional lever — *The switch from rectangular machined brass rod to a pressed brass powder part resulted in 1) elimination of 16 operations, 2) closer tolerances, 3) better nonrusting appearance without plating, and 4) a reduction in cost from $1.10 to 11¢ per part.*—Foxboro Co.

The physical characteristics of CLAD-REX® vinyl-metal laminate

The use of vinyl-clad metals is growing rapidly. The type and variety of vinyl-clad metals is increasing also. Although the various vinyl-clads compete for attention, they are not alike. Nor do they deliver similar advantage.

Therefore, your vinyl-clad metals data file should be assembled with care. Know exactly what you are considering, when to use it, and how.

At present there are two basic types of vinyl-clad metal available. One is a plastisol which is roller coated or sprayed on the metal substrate in liquid form. The other is a calendered vinyl film which is laminated to the metal substrate. Various levels of quality exist within both areas. However, the laminated type generally offers substantially broader advantage to the user than the plastisol—primarily within the areas of styling.

Because the characteristics can obviously vary in degree with the gauge of metal and film as well as texture and pattern of film, the following tabular data must be considered as typical:

	Properties of Film (8 Mil)	Properties of Laminate
Ultimate Tensile	4400 psi	Tensile of Supporting Metal
Ultimate Elongation	170%	Elongation of Supporting Metal
Tear Strength	910 lb. in.	Dependent on Metal Gauge
Bend Brittle, ¼" rod	—5° C.	—30° C.
Reverse Impact	Tears	120 in.—lbs.
Heat Deformation at 120° C. 2000 g. load	32%	30% (1 side)
Shrinkage 5 min. at 250° F.	4.6% with cal. grain	0.6%
	1.6% cross cal. grain	None

The durability of Clad-Rex vinyl-metal laminate

Although the sales appeal of unlimited styling is a major factor, perhaps the most important advantage offered by Clad-Rex vinyl-metal laminates is their durability. Clad-Rex *is* practical to fabricate. It can be processed in almost as many ways as any *un*finished sheet metal—including deep-drawing.

Coating	Mils Film Thick	Total Revolutions	Revolutions Per Mil Film Thick.*
Vinyl-Metal Laminate	4.0	8,430	2,108
Vinyl-Metal Laminate	8.5	17,156	2,100
Phenolic	1.25	1,204	1,000
Urea-Alkyd	1.70	122	72
Vinyl Lacquer Coating	2.0 Ave.	703-954	351-477

*Abrasion resistance determined with a Taber Abrader using a CS-10 wheel.

The corrosion resistance of Clad-Rex vinyl-metal laminate

The poly-vinyl chloride film used in Clad-Rex offers unusual resistance to chemicals. It will withstand acids, alkalis, alcohol, household detergents, salt water, industrial liquids, petroleum and corrosive atmospheres.

The cost advantage of Clad-Rex vinyl-metal laminate

As a purchased material going into a users plant, vinyl-metal laminates cost more than unfinished or some other prefinished metals. *But, most important, end products made of Clad-Rex generally cost less!*

The reasons are worthy of close examination:

1. Parts made of Clad-Rex require no further finishing. This means a savings in original equipment (including maintenance), finishing material, factory floor space, labor, handling, etc.

2. The abrasion resistance of Clad-Rex substantially reduces and often eliminates rejects. This means a savings in rejected products handling and expensive reworking activities.

	VINYL-METAL LAMINATE		PHENOLIC		ALKYD	
	Days Exp.	Result	Days Exp.	Result	Days Exp.	Result
10% Sulfuric Acid	17	OK	2	Failed	2	Failed
10% Nitric Acid	17	OK	2	Failed	2	Failed
10% Hydrochloric Acid	17	OK	2	Failed	2	Failed
10% Acetic Acid	17	OK	2	Failed	2	Failed
10% Lactic Acid	17	OK	17	Failed	2	Failed
10% Formaldehyde	17	Swelled	2	Failed	2	Failed
10% Caustic Potash	17	OK	3	Failed	2	Failed
Distilled Water	17	OK	17	Failed	2	Failed
Mineral Oil	17	OK	17	OK	17	OK
Ethanol	17	Sl. Shrink	17	OK	17	OK

A source of engineering and manufacturing service for you

Clad-Rex interest in helping you extends into your own plant. A Clad-Rex Fabricating Engineer is provided to show your production people how easy it is to process Clad-Rex.

Furthermore, Clad-Rex operates a fully staffed and equipped research laboratory. Its facilities are devoted to customer service as well as improving Clad-Rex itself.

Write and describe your product. See how Clad-Rex can work its broad effect on industrial design, engineering and selection of pre-finished metals in your product.

VINYL-METAL LAMINATES BY CLAD-REX DIVISION OF SIMONIZ COMPANY

2109 Indiana Avenue • Chicago 16, Illinois

Telephone: VIctory 2-7272

58

For more information, turn to Reader Service card, circle No. 534

If the cost of metal stampings and wire forms figures in your profit picture, let us give you a quotation on your current components. Send us a sample or blueprint . . . and discover how big savings in time and production costs, big gains in precision and uniformity are possible on small components, when Art Wire tackles the job!

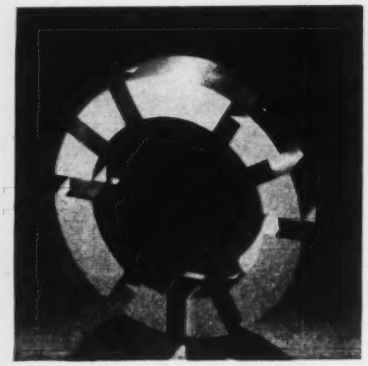
Our engineering staff, our production experience, and our modern high speed equipment are always at your disposal. If you wish to learn more about what a wide and versatile range of shapes and parts we can produce for you—at lower cost than you'd guess—just write for our illustrated folder.

ART WIRE AND STAMPING CO.

13 Boyden Place, Newark 2, N. J.

For more information, circle No. 410

MATERIALS AT WORK



Terminal block assembly — *By fitting this nickel silver part into a molded plastics block, and then machining away the base webbing, a saving of $1.97 per part was achieved. Formerly, the part was made by assembling individual terminals to a premolded block.*—Minneapolis-Honeywell Regulator Co.

inality and uniqueness of the application; 2) utilization of the special properties of nonferrous powder metallurgy; 3) the combinations of component functions; and 4) overall production economy accomplished by the design.

Combination Casting Produces Undercuts

By combining the techniques of plaster mold casting with those of investment casting, Atlantic Casting Engineering Corp. has produced nonferrous precision castings which are said to be impossible by either method alone.

In normal plaster mold casting, the molds are first formed around split brass positive patterns, and then dried, clamped and filled with molten nonferrous alloy. Obviously, only castings capable of being divided in two along the parting line can be produced.

In the combined technique, however, portions of a pattern that contain undercuts are cast in wax or plastic and attached to the withdrawable brass portion of the pattern. When the mold section is removed from the pattern, the wax or plastics portion detaches from the brass

HOW CHEM-O-SOL HELPED FRAM REDUCE MATERIALS AND ASSEMBLY COSTS

Fram satisfies both original equipment and replacement market requirements for a functional, economical, replaceable carburetor air filter with this simple, high speed method:

A measured amount of Chem-o-sol is dispensed automatically into a metal mold.

Filter element is embedded in the Chem-o-sol and the mold is then heated to convert Chem-o-sol to a solid.

Assembly is cooled enough to permit removal of the metal molds. Inspection and packaging complete the operation.

TECHNICAL FACTS ABOUT CHEM-O-SOL

COLOR CHOICE — unlimited
TENSILE STRENGTH — as required from 1000 psi. to 2700 psi.
PERCENT ELONGATION — 150 to 600
HARDNESS (shore A2) — as required from 10 to 100
(shore D) — up to 65
FLEXIBILITY — as required to temperatures as low as —65°F
CHEMICAL RESISTANCE — outstanding to most acids, alkalies, detergents, oils and solvents
HEAT RESISTANCE — available to 225°F for as long as 2000 hours and to 450°F for over two hours
DIELECTRIC STRENGTH — minimum of 400 volts per mil when fused in sections 3 mils thick and over
SOLIDS CONTENT — 100%. Chem-o-sols can be molded in very thick sections
VISCOSITY — as required for dipping, die wiping, molding, casting, spraying, or spreader coating

CHEMICAL PRODUCTS CORPORATION
King Philip Road
East Providence, R. I.

"Chem-o-sol helps us produce a vastly superior Fram automotive air filter at much lower cost"

says Chester A. Vander Pyl,
Chief Engineer
FRAM CORPORATION, PROVIDENCE, R. I.

"It's difficult to design a reliable air filter into the engine space of today's low-silhouette cars. But our new Fram *Filtronic*® carburetor air filter fills the bill. This 99%+ efficient air filter with its patented built-in gasket design saves installation time and costs us less to produce — thanks to Chem-o-sol.

"Formerly we used an elaborate combination of adhesives and stamped metal rings to hold the pleated paper element. We had to fabricate the ring, fabricate a cut gasket, adhere paper to metal, and adhere gasket to ring.

"Chem-o-sol, a flowed-in compound, replaces not only the metal to paper adhesive and stamped metal . . . but by serving as a gasket between housing and filter," explains Mr. Vander Pyl, "it also eliminates the extra gasket and its adhesive. We cut both the number of materials and steps from four to one. High speed molding helped us cut our costs 35%".

Chem-o-sol offers to manufacturers in a wide range of industries the serviceability of vinyl resin in an easily-handled *liquid* form. It permits the in-place molding of vinyl compounds so that they become an integral part of the final assembly. This labor-saving advantage makes possible the manufacture of products which were economically impractical prior to the development of Chem-o-sol.

Pioneering in the formulation of vinyl plastisols, Chemical Products Corporation has built the world's largest and most modern facilities for production and research of these materials. We think this labor-saving production tool could save *you* money, or improve your product. Write for our brochure "Chem-o-sol — Going Plastisols One Better". **Chemical Products Corporation, King Philip Rd., E. Providence, R. I.**

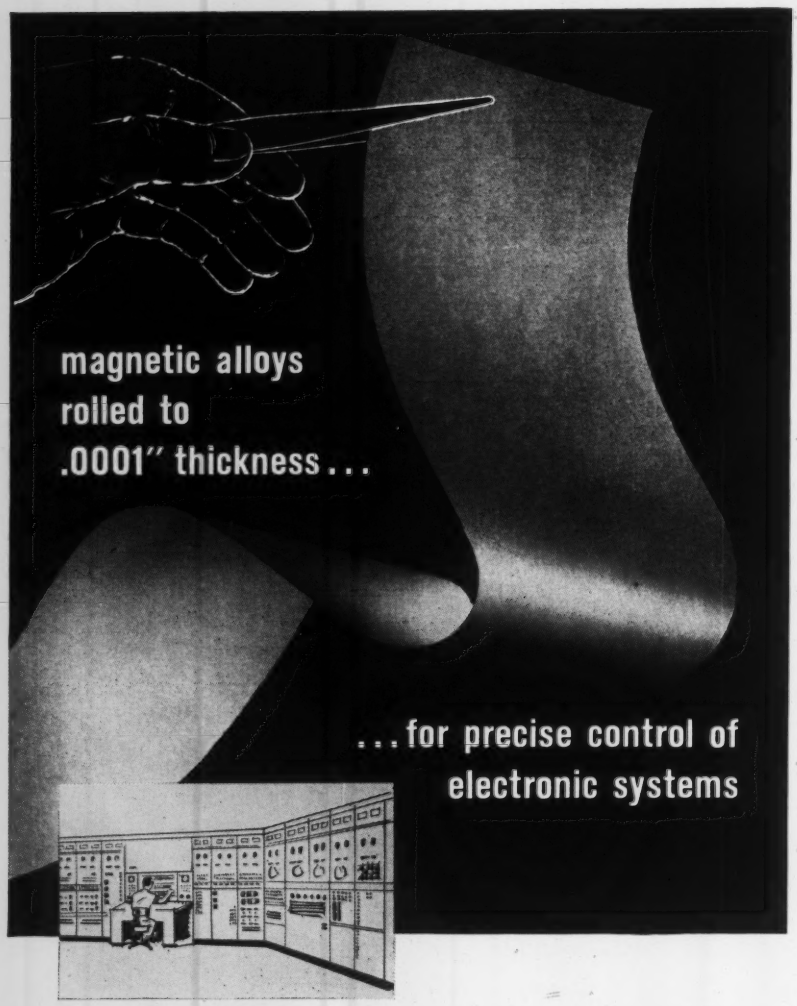
CHEM-O-SOL®

ALL THE ADVANTAGES OF VINYL RESIN IN AN EASILY-HANDLED LIQUID FORM

Other typical applications in which Chem-o-sol is saving industry time and labor

Clay Pipe Joints | *Screen Cloth* | *Wire Products* | *Mechanical Fasteners* | *Bottle Cap Liners*

For more information, turn to Reader Service card, circle No. 529



Now you can obtain high magnetic permeability alloys such as 4-79 Moly Permalloy, Alfenol, and HyMu "80" in cold rolled strip and foil in **production** quantities! The unique and newly expanded facilities of Precision Metals Division are geared to produce ultra-thin metal strip and foil in any quantity and in virtually any alloy.

Precision Metals strip and foil for development and production offer these special advantages:

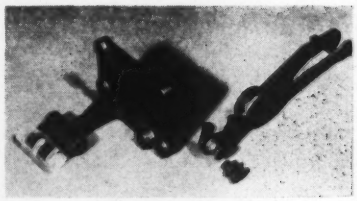
uniform magnetic properties
thicknesses from .010" to .0001"
dimensional uniformity
extremely close tolerances
excellent surface characteristics

For specific requirements, Precision Metals can also furnish custom alloys to your own specification in the form you need. Write today for fully illustrated facilities booklet, DE-9.

HAMILTON
WATCH COMPANY / **Precision Metals Division**
Lancaster, Pennsylvania

For more information, turn to Reader Service card, circle No. 517

MATERIALS AT WORK



***Plastic pattern** (left) and wax pattern (right) used to produce parts in combined plaster mold-investment casting technique.*

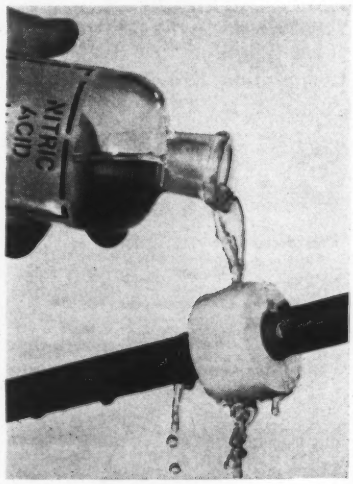
portion of the pattern and remains in the mold. It is later vaporized during the normal mold drying cycle.

The accompanying photo shows typical castings now in production which were considered impossible to produce by normal cope and drag techniques. Wax and plastics patterns are shown in relation to the part of the casting that they made possible. The castings are of manganese bronze.

Pyroceram Bearings Resist Hot Corrosives

Pyroceram is now being made into journal bearings which are said to be capable of operating with various metal shafts under highly corrosive conditions.

The material, described by Corning



***Hot nitric acid** does not affect Pyroceram journal bearings.*

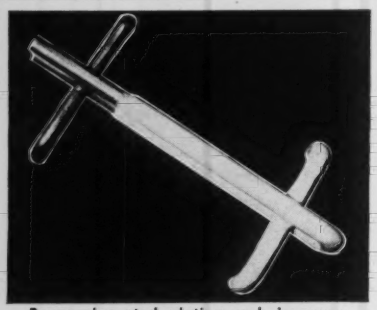
A new division of
The Dow Chemical Company—

THE DOW METAL PRODUCTS COMPANY

Here's significant news for everyone who has an interest in metals and metal fabrication. The Dow Chemical Company, pioneer developers of Magnesium and Magnesium products, is now broadening its activities in metal working. A new division, THE DOW METAL PRODUCTS COMPANY, has been formed to specialize in the semi-fabrication and fabrication of not only Magnesium, but aluminum and other metals. This new division has excellent production facilities, plus knowledge gained through Dow's many years' experience in the metal working field. Facilities include plants for the manufacture of rolled and extruded products, sand and permanent mold castings, die castings, and fabricated assemblies.

DOW THE DOW METAL PRODUCTS COMPANY
DIVISION OF THE DOW CHEMICAL COMPANY
MIDLAND, MICHIGAN

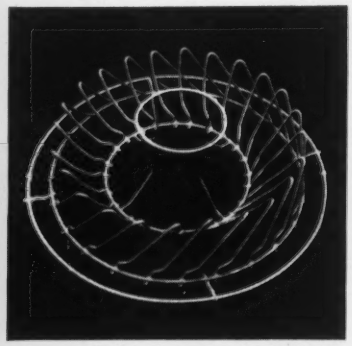
For more information, turn to Reader Service card, circle No. 539



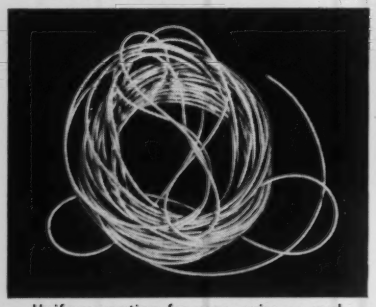
Reynosol coated plating rack increases product efficiency.

REYNOSOL* SOLVED THESE PROBLEMS

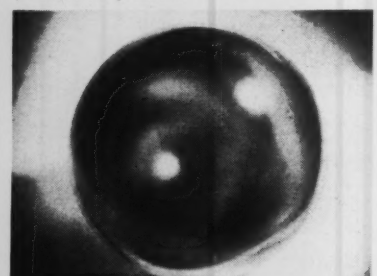
Hand tools are safer, sell better with Reynosol coating.



Years added to life of automatic dishwasher rack with Reynosol coating.



Uniform coating for rope, wire or cord offers no problem.



Reynosol is a national preference for all types of rotational castings.

WHAT CAN REYNOSOL DO FOR YOU?

Want a coating that's functional . . . decorative? Or maybe both? Your best bet, then, is to look to Reynolds Chemical Products Company — and to Reynosol.

Tough, attractive Reynosol can be formulated to meet your exact specifications—and in a full spectrum of color.

Let Reynolds Chemical creative scientists tackle your coating problem. They'll come up with exactly the answer—and the price—you've been hoping for.

REYNOLDS CAN COAT IT -- IF ANYONE CAN!

REYNOLDS CHEMICAL PRODUCTS COMPANY

Whitmore Lake, Michigan • Phone HIckory 9-9361
DIVISION OF STUBNITZ GREENE CORP.

*Reg. Trademark

For more information, turn to Reader Service card, circle No. 488

MATERIALS AT WORK

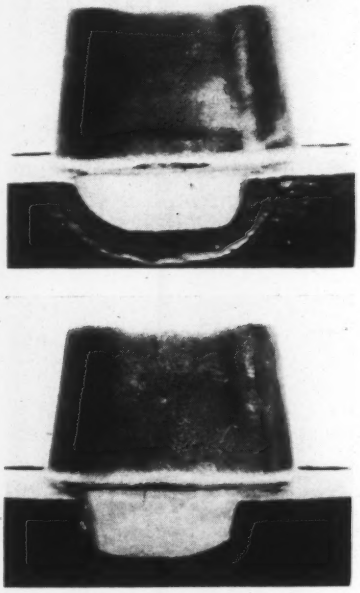
Glass Works as a high strength glass-ceramic, is reported to be particularly useful in the chemical and food processing industries because it will neither contaminate nor be affected by most chemical fluids. According to Corning, tests run in ferric chloride, nitric acid, sodium hydroxide, molten lead (700 F), citric acid and hydrogen peroxide indicate that the bearings resist all tendency to weld or score.

Results of sliding action tests indicate that Pyroceram bearings exhibit less friction, wear and surface damage than do standard bearing materials.

Molybdenum Cores Best for Die Casting

Molybdenum is now being successfully used as a core material for die casting aluminum, magnesium and brass.

According to the Die Casting Research Foundation, of the American Die Casting Institute the most com-



***Molybdenum die core** (above) remains smooth and clean after 5000 brass castings; steel die core (below) becomes rough and cracked under same conditions.*

COOPER ALLOY CASTINGS BRIEFS

THE CASTINGS ANSWER CORNER

Send in your questions on stainless steel castings to Carl Tylka, Cooper Alloy Technical Service Director.

Q. *What is the best all-around alloy for abrasion, wear, and corrosion resistance for use in waste disposal grinding units?*

A. Cooper AB-1 alloy, a high carbon chrome alloy with additions of molybdenum and vanadium.

Q. *What is meant by "ferroxyl quality" in evaluation of a stainless casting?*

A. This means a superior surface quality free from pinholes, porosity, scale particles, iron film, grease, or other undesirable conditions, as is guaranteed by passing the ferroxyl test.

Q. *Will stainless steel of the 18-8 type corrode in a moist atmosphere?*

A. Not ordinarily, but it will in contact with graphite.

Q. *Will annealing 12% chromium alloy make it more resistant to corrosion?*

A. No. Best corrosion resistance is obtained in the hardened or hardened and stress relieved condition.

Q. *Is 18-8S MO (316) better than 18-8S (304) for use in hot strong nitric acid?*

A. No, in this particular case 304 is better than 316.

Q. *Is 304 satisfactory for handling 70% sulfuric acid at room temperature?*

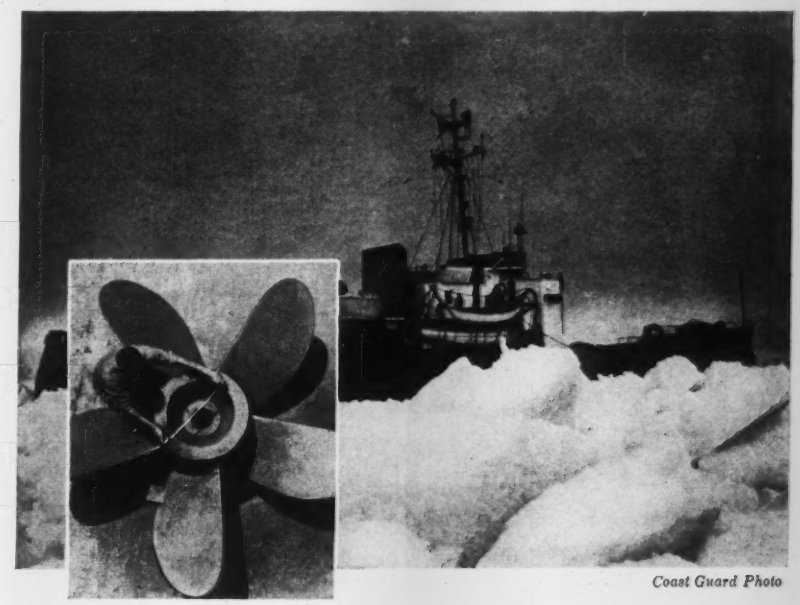
A. No. Believe it or not, carbon steel is satisfactory while 304 is not. If stainless is used, FA-20 must be resorted to.

Q. *Why is it that steel is resistant to 70% sulfuric acid, while stainless 304 is not?*

A. Because sulfuric acid forms an iron sulfate film on carbon steel which is insoluble in sulfuric acid of over 65% concentration, thus protecting the steel from further corrosion. This particular film does not form on stainless, which depends upon passivity for corrosion resistance. In 70% sulfuric acid passivity is lost and the stainless corrodes.

Q. *Is 316 alloy better than 304 for handling hot caustic solutions?*

A. No, 316 has no better resistance than 304 and FA-20. That is why monel is recommended. In extremely severe cases use pure nickel.



Coast Guard Photo

This Cooper Alloy casting helped break the ice for the Coast Guard in a tight situation

The casting is the five-bladed, 8½′ stainless steel propeller shown here. Cast by Cooper Alloy, it is used on Coast Guard icebreakers and buoy tenders like the one shown above in a historic tight situation. Even Washington crossing the Delaware was never subjected to a squeeze like this! This photo shows the Coast Guard buoy tender SPAR during her recent historic threading of the Northwest Passage.

This Passage is the tricky, winding, ice-ridden lane through Arctic waterways above Canada, from Labrador to Alaska. The 180-ft. SPAR and two sister ships made history when they recently completed the first deep-draft transit of the Passage, from west to east. During it, the ships were subjected to the worst ice and weather conditions of many years.

Breakdown under such conditions can mean real trouble. The situation, in fact, is tight in two ways: icewise, for the ship and crew; corrosionwise, for the metal parts exposed to the corrosive-erosive action of the Arctic sea water.

That's why stainless steel was chosen as the metal for the propeller. Sea water is highly corrosive to most metals, particularly as here when high-velocity erosion conditions are also present.

The problems surrounding the casting of a propeller of this size are enormous; but Cooper Alloy has had years of experience in handling just such tricky stainless casting assignments.

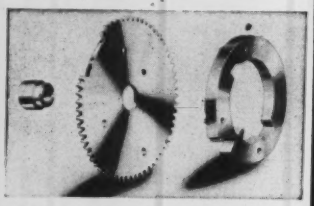
Whether your casting is large or small, tricky or straightforward, Cooper Alloy has the know-how and the facilities to do the job, and do it right. If *you* have a stainless part in mind, contact Cooper Alloy Corporation, Hillside, N. J.

For more information, turn to Reader Service card, circle No. 365

here's PROOF of how the GRC method cuts the cost of small parts...

Compare the methods for producing these mutilated gear, cam and bushing combinations . . . for an electrical appliance timer. (Shown actual size)

*method A

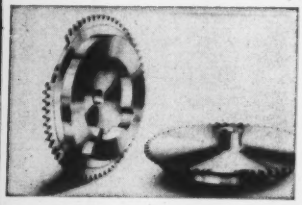


*Stamping, screw machine part, assembly

- Blanked, pierced, & extruded Cam
- Blanked & pierced Gear
- Screw Machined Bushing
- Sub-assembly: Stake Bushing to Gear
- Final Assembly: Stake Cam to Gear

5 PRODUCTION STEPS + 5 Inspections

the GRC method



One Piece—One Operation

Automatically Die Cast of Zinc Alloy

A BETTER PRODUCT
- Ready to use as cast
- Closer tolerances
- Higher uniformity
- No buckled gears & cams
- No loose assemblies
- No misalignment (gear-cam orientation . . . critical in this application)

SIMPLER PRODUCTION
- Cast and trimmed in one automatic step . . . no secondary operations
- No scrap loss

1 PRODUCTION STEP —only ONE Inspection Needed

NOW . . . compare these figures:

Cost/M in lots of

	100M	200M	500M	1MM
Method A	$32.50	$31.00	$30.00	$29.50
GRC Method	17.44	15.50	12.50	10.00

CLEAR SAVINGS FROM 50-60%

"BONUS FOR DESIGNERS" Only the GRC Method gives you such *complete freedom* for small parts. It turns many "impossible-to-make-at-any-price" ideas into uniform, high quality parts . . . at lower cost. So, before you design . . . check with GRIES.

You've seen the facts . . . clear proof of how GRC's DIE CASTING METHOD offers substantial savings on your small parts. The Gries Method delivers parts of high uniformity, with close tolerances . . . ready for use as they come from Gries' automatic machines. Assembly and most other secondary operations are eliminated.

MAXIMUM SIZE: 1¾" long, ½ oz. NO MINIMUM

Write, wire, phone NOW for GRC's bulletin "Small Die Castings Exclusively"; send prints for quotation.

GRIES REPRODUCER CORP.

World's Foremost Producer of Small Die Castings

153 Beechwood Ave., New Rochelle, N. Y. • NEw Rochelle 3-8600

For more information, turn to Reader Service card, circle No. 518

mon cause of die failure (particularly when casting the higher temperature metals) is heat checking or crazing. Because molybdenum offers "superior" resistance to heat checking and crazing, molybdenum die cores are said to last longer than cores made of such materials as standard stainless and die steels; chromium, nickel and cobalt-base alloys; cermets; and carbides.

Other advantages of molybdenum die cores are: reduction in downtime for polishing, and reduction in waste caused by tears on the casting surface.

Disadvantages of the molybdenum die cores are: lack of mechanical strength and ductility, low hardness, poor abrasion resistance, poor thermal shock resistance at lower temperatures, and high cost.

Acrylic Reel Cover Replaces Aluminum

The switch from punched aluminum to molded high-impact acrylic has enabled Denison-Johnson, Inc. to reduce costs and improve ruggedness of a hemispherical cover used to enclose and protect the spool and rotor of a fishing reel.

The previously used punched aluminum part required six finishing operations: 1) machining threads, 2) punching a hole for a line guide, 3) punching four drainage slots, 4) inserting and crimping the line guide, 5) buffing, and 6) anodizing. The new cover has wall threads, line guide, drainage slots, etc. molded directly into the part.

Other advantages of the acrylic cover include: 40% weight reduction; resistance to dents, scratches and weather; and excellent dimensional stability.

***Acrylic cover** provides better strength at one-third the cost of an aluminum cover.*

A new family of materials to meet special problems

•

SHOCK
STRESS
ABRASION

AMSCO® ALLOYS

In addition to austenitic manganese steel castings—long known for their exceptional service life in mining, construction, quarrying and milling applications—Amsco now offers *seven* other ferrous alloy materials. These include specially alloyed manganese steels, chrome moly steels, high strength alloyed steels and alloyed cast irons.

Each has particular advantages for specific service requirements, involving various combinations of impact, stress and wear. Check the brief facts on these alloys below. Then call in an Amsco sales engineer to assist in selecting the *one best* material to meet your application needs.

AMSCO ALLOY DESIGNATION	DESCRIPTION AND USES	MECHANICAL PROPERTIES
MY	Heat-treated, chromium alloyed manganese steel... for use in light-to-medium weight castings requiring modest improvement in growth and distortion, and increased stiffness.	tensile strength ..... 120,000 psi yield strength ..... 56,000 psi elongation ..... 45% reduction of area 30%
MML	Heat-treated, molybdenum alloyed manganese steel... for castings requiring improved weldability, for extremely heavy metal sections, and castings exposed to excessive heating environments.	tensile strength ..... 120,000 psi yield strength ..... 52,000 psi elongation ..... 50% reduction of area 40%
MMH	Heat-treated, molybdenum alloyed manganese steel... for use in castings requiring optimum mechanical properties and wear resistance. Provides improved stiffness and resistance to peening and flow.	tensile strength ..... 120,000 psi yield strength ..... 65,000 psi elongation ..... 20% reduction of area 18%
CML	Heat-treated, air-hardening chrome-moly steel... for casting applications involving scouring or grinding wear. Suitable for more complex casting designs.	tensile strength ..... 155,000 psi yield strength ..... 130,000 psi elongation ..... 10% reduction of area ..... 15% hardness ..... 275-375 BHN
CMH	Heat-treated, air-hardening chrome-moly steel... exhibits potentially improved wear resistance over CML (above), when shock loading is not sufficiently severe to cause breakage.	tensile strength ..... 155,000 psi yield strength ..... 130,000 psi elongation ..... 6% reduction of area ..... 7% hardness ..... 300-400 BHN
CS	Martensitic, multiple alloy steel with chromium, nickel and molybdenum... combines high mechanical strength with good abrasion and wear resistance.	tensile strength ..... 220,000 psi yield strength ..... 195,000 psi elongation ..... 8% reduction of area ..... 20% hardness ..... 300-500 BHN
HC	High chromium cast iron... provides outstanding abrasive wear resistance, where impact force is low but particle velocity and scouring forces are high.	tensile strength ..... 60,000 psi transverse strength ..... 7,000 lbs. deflection ..... 0.12 in. hardness ..... 400-600 BHN

For further information
—write for technical bulletin on "Amsco Ferrous Alloy Castings".

AMERICAN Brake Shoe COMPANY

AMSCO

American Manganese Steel Division • Chicago Heights, Illinois

Other Plants in: Denver • Los Angeles • New Castle, Delaware • Oakland, California • St. Louis
In Canada: Joliette Steel and Manitoba Steel Foundry Divisions

For more information, turn to Reader Service card, circle No. 423

For your specialized adhesive problems, call on *Ray-BOND*® adhesive specialists

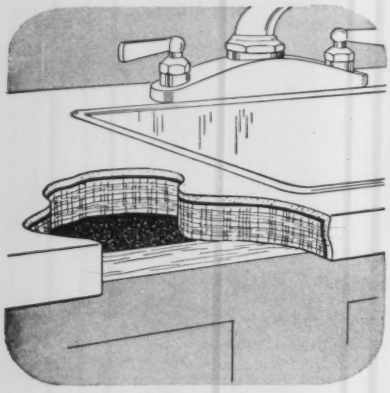
FOR THESE AND 1001 OTHER APPLICATIONS, NEW R/M RAY-BOND ADHESIVES CAN BE TAILORED TO YOUR NEEDS

Many of your fabrication and assembly problems can be solved quickly and economically with the wide range of Ray-BOND thermosetting and thermoplastic adhesives manufactured by Raybestos-Manhattan. For special requirements, R/M will tailor special adhesives . . . designed to meet your own particular manufacturing techniques, the demands of the materials you are using, and the service conditions of the product itself.

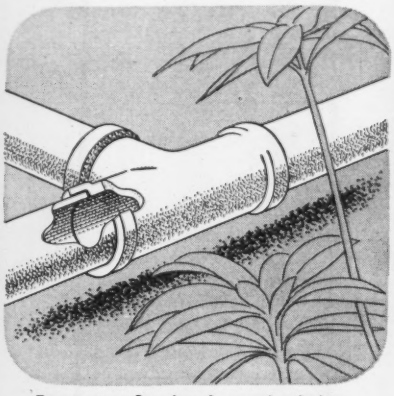
Whichever you use, you can be sure that Ray-BOND will help you cut expenses, speed production, and simplify your operations. You can assemble complex shapes, bond parts of dissimilar materials, and do away with rivets and other fasteners. Your products will be able to withstand extremes of heat and cold and will have greater conductivity.

If bonding, laminating, sealing or coating can cut costs or improve production in your own operations, call on Raybestos-Manhattan engineers today.

R/M Bulletin No. 700 contains engineering information you will want on Ray-BOND adhesives, protective coatings and sealers. Write for your free copy.

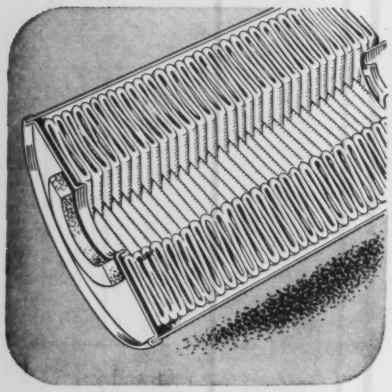


Bonding cabinet top to base.

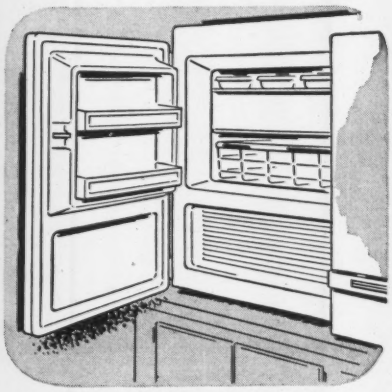


To create a firm bond on polyethylene plastic sewer and irrigation pipe.

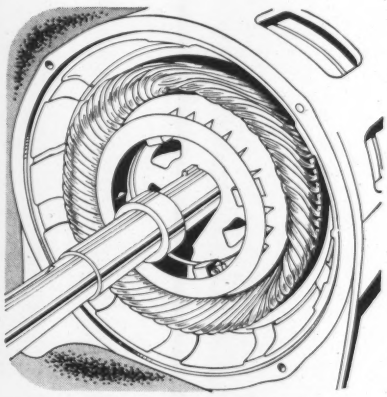
Bonding friction materials to metal.



Bonding paper to cork, aluminum or other metals for use in oil filter.



Bonding laminated panels of new plastic refrigerator.



Adhesives keep armature coil windings in place under severe operating conditions.

R/M

RAYBESTOS-MANHATTAN, INC.

ADHESIVES DEPARTMENT: Bridgeport, Conn.

Chicago 31 • Detroit 2 • Cleveland 16 • Los Angeles 58

FACTORIES: Bridgeport, Conn.; Manheim, Pa.; Passaic, N.J.; No. Charleston, S.C.; Crawfordsville, Ind.; Neenah, Wis.; Paramount, Calif. Raybestos-Manhattan (Canada) Limited, Peterborough, Ontario, Canada

RAYBESTOS-MANHATTAN, INC., Industrial Adhesives • Brake Linings • Brake Blocks • Clutch Facings • Industrial Rubber • Engineered Plastics • Sintered Metal Products Rubber Covered Equipment • Asbestos Textiles • Laundry Pads and Covers • Packings • Abrasive and Diamond Wheels • Bowling Balls

For more information, turn to Reader Service card, circle No. 389

Prices of Materials

Changes since last semi-annual report in March are bold-faced

NONMETALLICS

Prices for large quantities for range of grades, color, sizes; given in $/lb

RUBBER

Material	Dry	Latex
Butadiene-Acrylonitrile	.49-.68	—
Butadiene-Styrene	.14-.30	.26-.54
Butyl	.23-.28	—
Neoprene[a]	.39-.75	.37-.50
Silicone[a]	1.90-4	—
Polysulfide[a]	.50-1.25	.80-1.25
Natural[b]	.34	—

[a]Less than carload quantities.
[b]Average spot price for month of June.

REINFORCED PLASTICS LAMINATE SHEET

Type	0.025-¼ In.	⅜-2 In.
Paper-Base Phenolic (X, P, PC, XX, XXP, XXX, XXP)	1.03-1.50	.82-1.22
Cotton Fabric-Base Phenolic (C, CE, L, LE)	1.20-2.20	1.36-1.76
Asbestos-Base Phenolic (A, AA)	1.20	.96-2.70
Glass-Base Phenolic (G-3)	3.25	2.60
Glass-Base Melamine (G-5)	2.88	2.30
Glass-Base Silicone (G-7)	6.65	5.90
Nylon-Base Phenolic (N-1)	4.43	3.54

THERMOSETTING PLASTICS

Material	Molding Compounds	Laminating, Casting Resins
Alkyd	.39-.53	—
Epoxy	—	.45-.80
Melamine	.42-.45	.40-.41
Phenolic	.20-.35	.17-.34
Polyester	.33-.44	.33-.53
Silicone	2.75-5.40	1.55-1.74[a]
Urea	.19-.34	—

[a]60% solids content.

All prices are approximate and given solely for general guidance of those responsible for materials selection.

THERMOPLASTICS

Material	Molding Compounds	Sheet (.030-.250 in.)	Rod		Tube	
			⅛-¼ in.	⅜-1¼ in.	⅛-¼ in.	⅜-1¼ in.
Acrylic	.55-.59	.49-2.15	.90-1.15	.80-.90	1-1.15	.90-1
Cellulosic						
Acetate	.36-.58	.92-1.16	.75-1	.65-.75	.85-1	.75-.85
Butyrate	.40-.62	1-1.28	.95-1.20	.85-.95	1.05-1.20	.85-1.05
Nitrate	—	1.60-2.73	1.45-1.75		2.25-5.00	
Propionate	.62	—	—		—	
Fluorocarbon						
CFE	7-8	15-23	18-22	14-20	20-22.50	16-20
TFE	4.10-6.65	14.30-11	13	13	13	13
Nylon	1.18-2.18	—	3	3	3	3
Polyethylene	.35-.56	.85-1	.75-1	.65-.75	.85-1	.75-.85
Polystyrene	.22-.44	.57-.61	.65-.90	.55-.65	.75-.90	.65-.75
Vinyl	.24-.43	.62-.92	.75-1	.65-.75	.85-1	.75-.85

NONFERROUS METALS

Mill base prices for large quantities; given in $/lb except where indicated

ALUMINUM

Pig (99-99.9%)	.25
Ingot (99-99.9%)	.27
Foil (5-0.5 mil)	.58-.59
Alloy Ingot (13, 43, A132, 214)	.29-.31
Sheet (1100, 3003; 3-0.03 in.)[a]	.43-.46
Plate (1100, 3003, 5050, 3004, 5052)[a]	.43-.53

[a]Mill finish.

BRASS

Form	Cart., 70%	Low, 80%	Red, 85%
Sheet, Strip	.47	.50	.51
Seamless Tubing	.51	.53	.54
Rod (not f.c.)	.47	.50	.51
Wire	.48	.51	.52

COPPER

Ingot (elec)	.30
Sheet, Strip (hot rolled)	.52-.54
Seamless Tubing	.54
Rod, Drawn	.51
Wire	
Round	.35
Square, Rectangular	.39
Magnet	.41

LEAD

Common Grade	.12

MAGNESIUM

Pig (98.8%)	.35-.37
Ingot (98.8%)	.36-.37
AZ91B Ingot (die casting)	.37
AZ91C Ingot (sand casting)	.41

NICKEL

Form	"F"	"A"	Monel
Ingot	.75	—	—
Rod	—	1.07	.89
Sheet, C.R.	—	1.38	1.20
Strip, C.R.	—	1.24	1.08
Seamless Tube	—	1.57	1.29

TIN

Straits[a]	1.02

[a]Spot.

(continued on p 208)

FOR HIGH SPEED FABRICATION

NEW INSUROK®

Free-Machining, Laminated, Rolled Tubes Meet Mil-P-79B and Federal L-L-31

INSUROK GRADE	NEMA GRADE	MILITARY SPECIFICATIONS	FEDERAL SPECIFICATIONS
T-300	X	Mil-P-79B, Type PBM, Form TR	L-L-31, Type 1, Grade X
T-301	XX	Mil-P-79B, Type PBG, Form TR	L-L-31, Type 1, Grade XX

T-300 and T-301—two new, improved grades of INSUROK paper base, laminated tubes are distinguished by their excellent FREE MACHINING characteristics. They do not chip or delaminate when fabricated. Having good dielectric properties and uniform appearance, these light colored INSUROK tubes are suited to any fabricating operation. You can machine INSUROK T-300 and T-301 at top operating speeds.

For your electrical and mechanical applications you are offered a wide choice of tube sizes in these new grades:

• Inside diameters up to 12 inches • Wall thicknesses up to 2 inches

CHARACTERISTIC PROPERTY COMPARISON

CHARACTERISTIC PROPERTIES	NEMA XX REQUIREMENTS	T-301 TYPICAL VALUES
	Test Samples From 1" x 1¼" Tubes	
Water Absorption	2% maximum	1%
Density (grams per CM^3)	1.12 minimum	1.25
Dielectric Strength (perpendicular to laminations)	290 volts/mil. minimum	400 volts/mil.

Richardson offers a complete line of INSUROK laminated grades in sheets, rods and tubes . . . also provides complete fabrication service at its Melrose Park, Illinois and New Brunswick, New Jersey plants.

For full information on INSUROK T-300 and T-301, write direct or contact sales offices in principal cities.

the RICHARDSON COMPANY

LAMINATED AND MOLDED PLASTICS Founded 1858

2782 LAKE STREET • MELROSE PARK, ILLINOIS • SALES OFFICES IN PRINCIPAL CITIES

For more information, turn to Reader Service card, circle No. 489

PRICES AND SUPPLY

TITANIUM

Sponge (99.3+%)	1.50-1.60
Bars, Rod	4.25-7.50
Plate	5.25-10.00
Sheet, Strip	7.25-17.00
Wire	5.75-10.00

ZINC

Prine Western	.11½
Die Casting Alloys[a]	.14
Sheet	.26
Ribbon	.22
Plates	.20

[a]Alloys 2, 3, 5.

METAL POWDERS

Aluminum [a,b]	.39
Brass[a]	.34-.50
Copper (elec or red.)[a]	.44
Molybdenum (98%)	3.15-4.10
Nickel	1.05
Tantalum	49
Tungsten (C-red. 98.8%; H_2-red. 99+%)	3-4[c]
Zirconium	
Flash Grade	4
Electronics Grade	15

[a]Price for —100 mesh. [b]Freight allowed. [c]Delivered price.

OTHER NONFERROUS METALS

Cadmium (bars)	1.30
Columbium	55-85
Gold	$35/troy oz
Indium (99.97+%)	$2.25/troy oz
Manganese (99.9%)	.34-.38[a]
Palladium	$18-20/troy oz
Platinum	$77-80/troy oz
Silver	90-91¢/troy oz
Tantalum (sheet, rod)	55-60
Vanadium (90%)	3.45
Zirconium (sheet, strip, bar)	20-30

[a]Delivered price.

IRONS AND STEELS

Mill base prices for large quantities

SEMIFINISHED STEEL ($/net ton)

Ingots, Alloy	82
Billets, Blooms, Slabs	
Carbon, Re-Rolling	80
Carbon, Forging	99.50
Alloy, Forging	119
Seamless Tube Rounds	122.50
Wire Rods	$6.40/cwt

(continued on p 210)

Meet the "MECHANICAL CHEF"...

and its helper, *Stainless Steel!*

Ravioli is destined for even greater popularity . . . thanks to this unique "mechanical chef".

With it, volume production is possible—quality can be easily maintained. The operator simply fills the hoppers—the "chef" automatically rolls the dough, inserts the stuffing, shapes and cuts the ravioli...at *18,000* pieces per hour. Dough thickness and stuffing quantity can be precisely controlled for uniform taste and peak flavor.

Stainless steel is specified for all working parts . . . to assure purity, meet sanitary codes. Stainless provides corrosion resistance, easy cleaning—and economy, through trouble-free operation and extended life. The ravioli "chef" is made of stainless steel rounds, squares, flats, sheets—even *welded* and *seamless* tubing. And every bit of stainless is obtained *overnight*—from Frasse.

It pays, when you're working with stainless, to work from Frasse stocks. Frasse carries every rolled form—in a wide range of sizes and analyses... delivery is immediate. You'll like the freedom of choice Frasse stainless stocks provide...find satisfaction in having a reliable source for *everything* in stainless. Call us.

Call FRASSE 1st for

COMPLETE

STAINLESS STEEL SERVICE

Bars	Tubing
Forgings	Pipe
Sheets	Wire
Strip	Fittings
Plates	Valves

AMERICAN STEEL WAREHOUSE ASS'N
YOUR STEEL SERVICE CENTER

Peter A. Frasse & Co., Inc.

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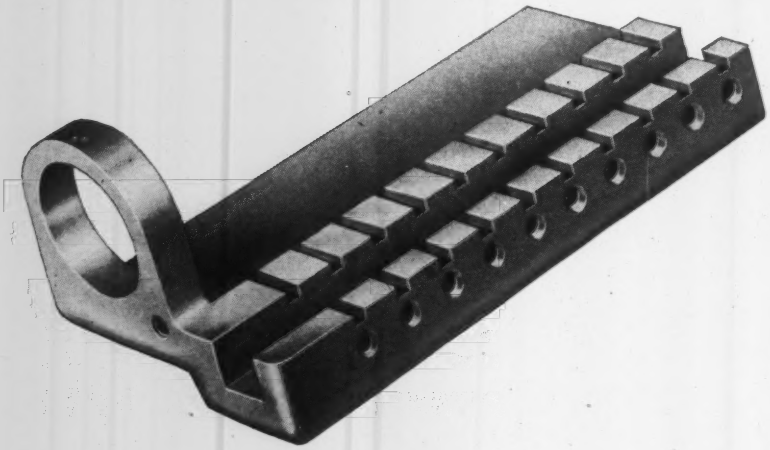
For more information, turn to Reader Service card, circle No. 421



IBM *specified die casting* ...to save machining

How else could this International Business Machines part be made?

It could be milled, machined and bored. But costs would be exhorbitant. It could be cast by other methods. But accuracy and subsequent machining operations would be costly.

Look at the job! 12 cores, 10 slotted surfaces, planes on varying levels. Tolerances as exacting as ± .002, non-accumulative between holes and slots.

IBM desired to eliminate post-casting operations. Twin City Die Castings made die and castings to meet exacting requirements. Result: costs held, performance insured, the die casting process demonstrated its flexibility.

Perhaps die casting can pay you in precision, appearance, fewer assembly steps . . . by cutting your costs. Call or write. A Twin City Die Castings engineer can help die casting pay for you.

...only DIE CASTING can
✓ cut your costs ✓ offer such flexibility
✓ provide such accuracy

Leading Die Casters in the Upper Midwest

TWIN CITY DIE CASTINGS CO.

3351 TALMADGE AVE. S. E. • MINNEAPOLIS 14, MINN. • PHONE MI 6-7528

For more information, turn to Reader Service card, circle No. 471

PRICES AND SUPPLY

FINISHED STEEL (¢/lb)

Form	Carbon	High Str Low Alloy	Alloy
Plate	5.30	7.95	7.50
Sheet, H.R.	5.10	7.52	—
Sheet, C.R.	6.27	9.27	—
Strip, H.R.	5.10	7.57	8.40
Strip, C.R.	7.42	10.80	—
Bar, H.R.	5.67	8.30	6.72
Bar, C.F.	7.65	—	9.02

STAINLESS STEELS ($/lb)

Material	Forging Billets	H. R. Bars	Plate	Sheet, Strip
Austenitic				
301, 302, 302B, 303, 304, 305	.39-.44	.46-.50	.41-.46	.51-.55
321[a]	.49	.58	.55	.66
347[a]	.58	.67	.65	.79
Martensitic				
410[a]	.29	.35	.30	.40
416	.30	.36	.31	.48
403	.29	.35	.30	.40
420, 440	.36	.43	.40	.62
Ferritic				
405, 430, 430F[a]	.30	.36-.37	.31-.33	.47-.52
442	.33	.40	.37	.56
431	.39	.46	.41	.56
446	.41	.48	.43	.70
High Mn				
202[a]	.38	.45	.40	.49
Extra Low C				
304L	.50	.57	.54	.63
316L	.72	.84	.80	.89
Precip Hard.				
17-7PH	.69	.76	.85	.90
PH 15-7 Mo	.89	.97	1.11	1.16

[a]Ingot price approx 60% of billet price.

METAL POWDERS ($/lb)[a]

Sponge Iron	.11
Electrolytic Iron	
Annealed (99.5%)	.37
Unannealed (99+%)	.36
Stainless Steel	
304	.89
316	1.07

[a]Price for —100 mesh.

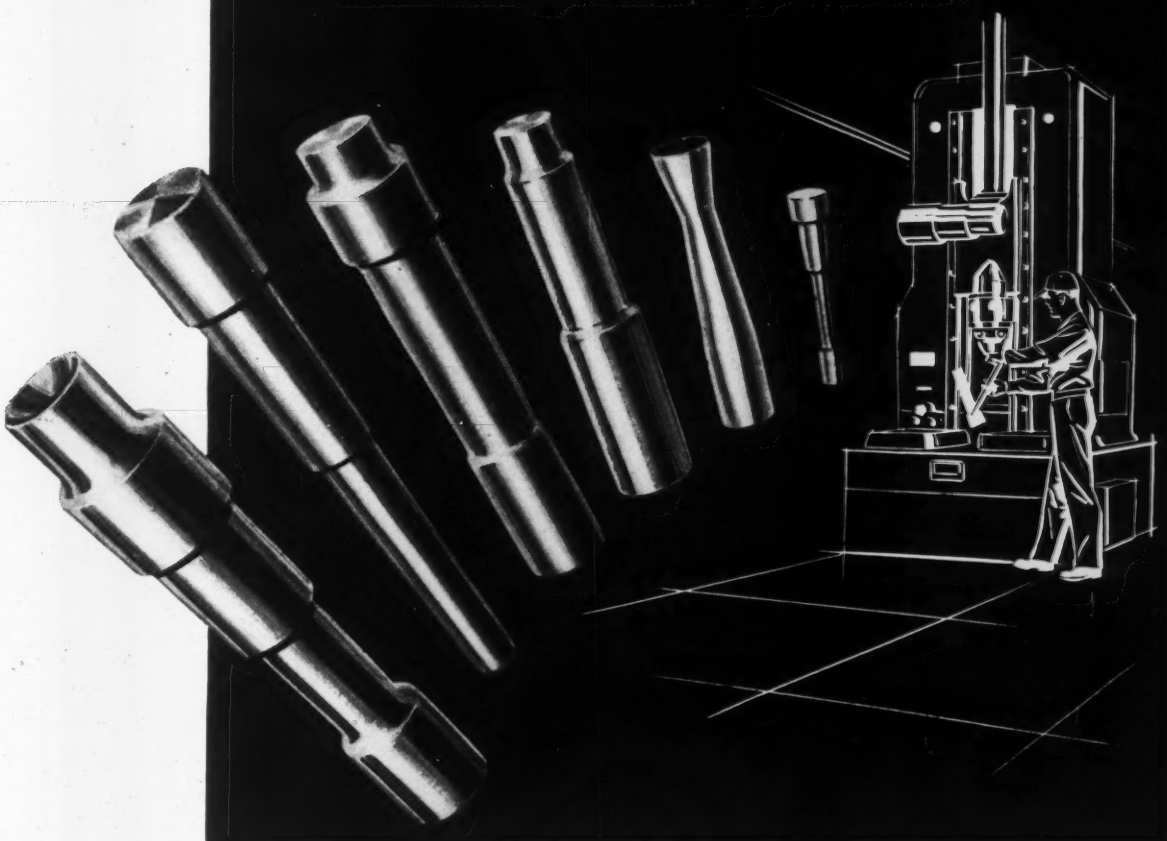
IRON ($/gross ton)

Pig	66-67

(continued on p 212)

Two big advantages!

CURMET Rotary Forging stops strength loss in premium alloys - cuts scrap loss up to 57%



One prominent manufacturer saved 37½% in "K" Monel bar costs—found that the characteristics of the metal were vastly superior when it was CURMET rotary forged rather than machined. Other users report 25% . . . 13½% . . . 38% . . . even 57% saved in premium quality alloys—and the same improved properties in the finished product.

To get maximum strength from premium alloys, grain flow lines must remain intact. CURMET rotary forging stops strength loss because it eliminates cutting through these vital grain flow lines—keeps metal stamina up. In addition, this method minimizes waste of expensive metal stock by redistributing the metal instead of cutting it away. Scrap losses are always less.

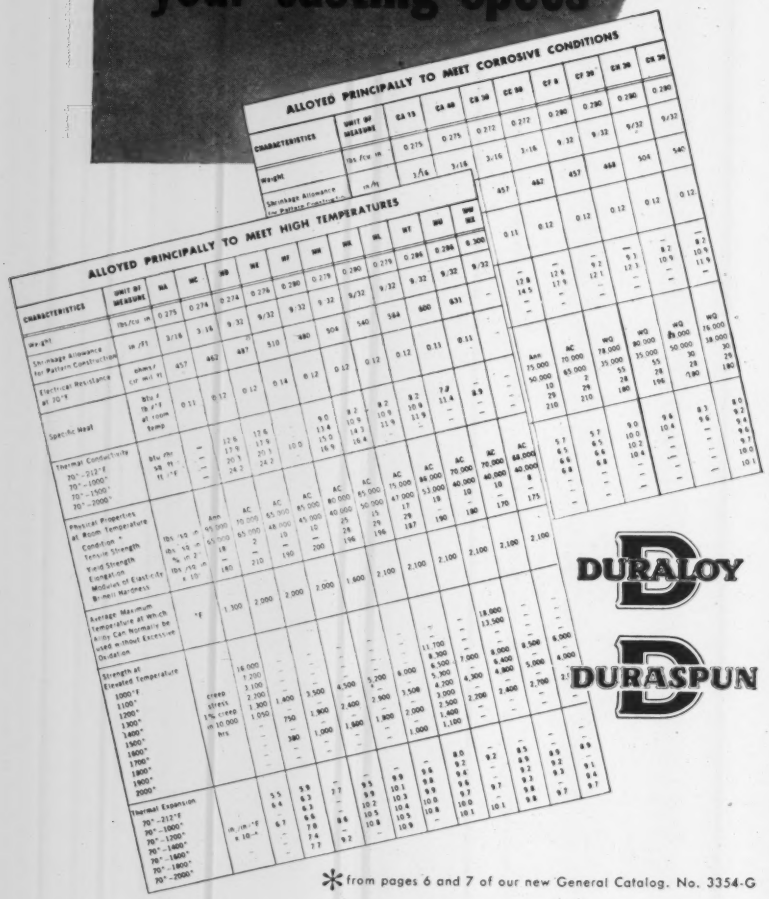
When you require multi-diameter forgings measuring up to four inches and not over four feet in length—investigate CURMET rotary forging. The Curtiss-Wright engineer will be pleased to estimate *your* savings. And he will give you more information on the superior properties that the process achieves in metals.

Write us now for the completely new brochure on the CURMET rotary forging process.

CURTISS-WRIGHT CORPORATION 76 GRIDER STREET **METALS PROCESSING DIVISION** BUFFALO 15, NEW YORK

For more information, turn to Reader Service card, circle No. 461

TABLES to help you select the proper alloy for your casting specs



DURALOY

DURASPUN

*from pages 6 and 7 of our new General Catalog. No. 3354-G

— and there's lots more useful information about high alloy castings in our up-to-date catalog describing Duraloy Service. SEND FOR YOUR COPY.

As one of the pioneers in both static (1922) and centrifugal (1931) high alloy castings, we have a wealth of experience to focus on your high alloy casting problem. Send for our catalog, study it, and then let us help you get the best alloying combination to solve your corrosion, high temperature and/or abrasion problem.

The DURALOY Company

OFFICE AND PLANT: Scottdale, Pa.

EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
ATLANTA OFFICE: 76—4th Street, N.W.
CHICAGO OFFICE: 332 South Michigan Avenue
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

For more information, turn to Reader Service card, circle No. 387

PRICES AND SUPPLY

CLAD STEELS (¢/lb)[a]

Cladding Metal	10%	15%	20%
Stainless			
304	29	32	34
304L	34	37	40
316L	47	51	56
321	35	38	41
347	41	45	49
430	23	26	28
Inconel	60	70	81
Nickel	52	63	73
Monel	54	64	74

[a]Prices given for three cladding thicknesses.

TIN PLATE ($/base box)

Hot Dip (1.25-1.50 lb)	10.40-10.65
Electrolytic (0.25-0.75 lb)	9.10- 9.75
Black Plate	8.20

FINISHES AND COATINGS

ORGANIC COATINGS

Material	Avg Thk per Coat, mil	Mils Required[a]	Cost, ¢/sq ft/dry mil[b]
VARNISHES, ENAMELS			
Short Oil Phenolic			
Varnish	1.0	1.0	1.5
Enamel	1.2	1.0	1.75
100% Phenolic	1.0	1.5	1.75
Straight Oil-Modified			
Alkyd	1.5	1.5	1.5
Alkyd-Amine (90-10)	1.5	1.5	1.75
Alkyd-Phenolic (50-50)	1.5	1.5	1.75
Alkyd-Vinyl (50-50)	1.0	2.0	2.0
Alkyd-Styrene (70-30)	1.2	1.5	1.75
Epoxy	1.8	1.8	2.0
Silicone	.5-1.0	.5-1.0	6.0
Furane	2.0	2.0	1.0
Neoprene	5.0	5.0	1.5
DISPERSION COATINGS			
Phenolic	1.0	1.5	1.75
Vinyl	1.0	2.0	2.5
Fluorocarbon	1.0	1.0	15.0
LACQUERS			
Nitrocellulose	1.0	2.0	2.5
Vinyl	1.0	2.0	2.5
Acrylic	1.0	2.0	2.75
Butyrate	1.0	2.0	2.75

[a]Thickness over phosphate coating required for exterior durability on steel. For purely decorative coating, 1 mil will usually suffice.
[b]Materials cost only. Realistic price comparison can be made only on basis of dry applied coating, not on basis of cost per gallon.

For more information, circle No. 498 ➤

SYNTHETIC SAPPHIRE FOR HELIX SUPPORTS

The bifilar helix and electron gun structure of this backward wave oscillator tube are supported by sapphire rods. The tube was developed and built at the Electronics Research Laboratory, Stanford University, and operates from 500 to 1000 megacycles at 100 watts.

Single crystal synthetic sapphire rods are being used as support members for TWT helices and electron gun structures.

Sapphire offers flexural strength at elevated temperatures, excellent dielectric properties, small-diameter rigidity, strength at elevated temperatures, low-loss characteristics, zero porosity, and economy.

In addition to rods, single crystal sapphire is available in the form of windows and domes for microwave and infra-red systems. Special sapphire shapes for custom applications can be obtained.

Other single crystals, such as ruby and doped titania for maser amplifiers are available. LINDE also supplies single crystal yttrium iron garnet, for solid-state devices.

For further data, write to Linde Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. *In Canada:* Linde Company, Division of Union Carbide Canada Limited. Address Department MI-09

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UNION CARBIDE

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#4 CHARACTERISTICS OF HONEYCOMB

While honeycomb has found its greatest application in composite sandwich structures it is expected that a broad area of application will appear as a result of some of the lesser known properties of this material.

Basic Geometry

Hexcel honeycomb is made by laminating strips of foil together with adhesive lines located in such a manner that the resulting bonded stack can be expanded to form hexagonal cells. Figure 1 illustrates various degrees of expansion.

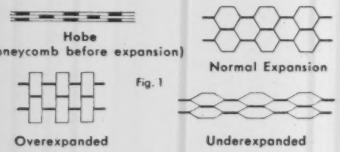

Fig. 1

This basic geometry provides:

1. An extremely high ratio of exposed surface area to the total volume.
2. Virtually all the exposed area is enclosed in regularly oriented unidirectional cells.
3. By varying the cell size and the degree of expansion virtually unlimited adjustment of the foil area to volume relationship may be obtained, as shown in Figure 2.
4. Fluids or gases transmitted through this honeycomb material all travel in the same direction and are uniformly exposed to the surface area.

Physical sizes available include hexagonal cell sizes from $\frac{1}{8}$ inch to $1\frac{1}{2}$ inch, cell depths from .060 to 24 inch, and piece sizes up to 42 inch by 96 inch.

5478

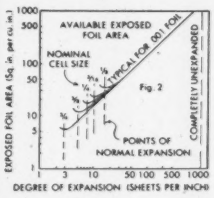
AVAILABLE EXPOSED FOIL AREA
NOMINAL CELL SIZE
TYPICAL FOR .001 FOIL
POINTS OF NORMAL EXPANSION
COMPLETELY UNEXPANDED
EXPOSED FOIL AREA (Sq. in. per cu. in.)
DEGREE OF EXPANSION (SHEETS PER INCH)

Fig. 2

Air Directionalizing

The uniform and parallel cell orientation of expanded honeycomb gives it rather unusual properties in directionalizing air and fluid flow and in minimizing turbulence and rotational flow. Extremely small edge areas of the .001 inch to .004 inch foil used results in a low pressure loss. These properties have been used in applications from home coolers and grilles to wind tunnel straightening vanes. A piece of honeycomb oriented at an angle to the direction of flow can be used as a directionalizing material. Figure 3 illustrates the efficiency of honeycomb as used in grilles and registers.

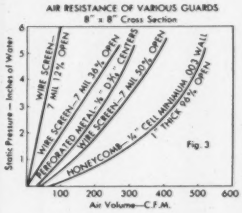
AIR RESISTANCE OF VARIOUS GUARDS
8" x 8" Cross Section
WIRE SCREEN—7 MIL 35% OPEN
WIRE SCREEN—7 MIL 63% OPEN
REFORMED METAL—¼" CENTERS
WIRE SCREEN—7 MIL 50% OPEN
HONEYCOMB—½" CELL MINIMUM .002 WALL 1" THICK 98% OPEN
Static Pressure—Inches of Water
Air Volume—C.F.M.

Fig. 3

RF Noise Filters

Honeycomb has been used in the grilles and registers of shielded radio equipment. In this application, honeycomb acts both as an RF shielding device and as an efficient air directionalizing device. It is effective as an RF shield for all frequencies below the cut-off frequency of the cell size and thickness used.

Light Directionalizing

One grade of aluminum honeycomb, "HONEYLITE", has found wide application as a lighting louver, particularly in overall luminous ceiling applications. This characteristic of honeycomb indicates broader use in the collimation of not only visible light, but also ultraviolet and infrared.

Heat Exchangers

The extreme high ratio of surface area to unit volume provided by honeycomb materials can offer many possibilities in heat exchanger applications. Materials available for use in this application include two aluminum alloys plus a variety of stainless steel alloys, in both resin bonded and welded node construction.

Anti-Slosh Devices

Honeycomb has been used as a baffle or anti-slosh device both in fully enclosed sandwich fuel cell structures and in non-sandwich applications. The material can be readily drilled for lateral flow from cell to cell.

Design Opportunities

It can be seen that honeycomb offers to the designer many properties and possible combinations of properties which open up wide areas of potential application. The applications themselves seem limited only by the imagination of those who make use of the material.

Others in This Series. Copies sent on request

1. **Honeycomb Sandwich Panels**
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Sales Offices: Long Island City, N.Y.; Fort Worth, Texas; Inglewood, Calif.

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Research Programs Aim for Better Materials

Four new research projects concerned with the development of new and/or improved engineering materials and processes have been announced recently:

▸ New or improved steels for nuclear power reactors is the major goal of a testing and development program recently begun by General Electric Co. and U. S. Steel Corp.

The approach will be as follows: a wide variety of steels will be tested for corrosion resistance under conditions similar to those in boiling water reactors. The best of these steels will then be exposed to GE's test reactor. Information provided by the tests will then be used to develop new steels.

In another phase of the program, the effects of high intensity neutron irradiation on the properties of pressure vessel steels will be studied.

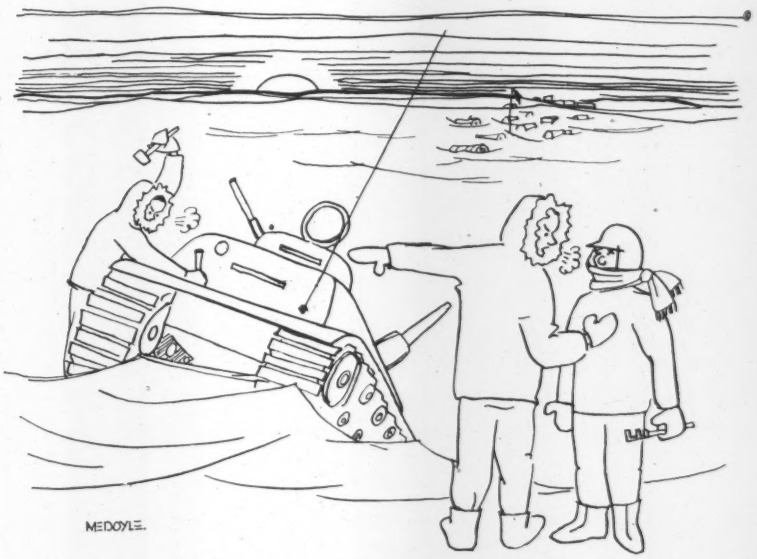
▸ Improving the durability and versatility of high impact polystyrene, nylon-6 and styrene acrylonitrile will be the primary objectives at Foster Grant Co., Inc.'s new research center. Basic studies of new polymers and processes will also be carried out.

According to the company, research will be divided into three general areas: chemical research, process development, and product development.

▸ Extensive research and development of the processing, packaging and uses of isotopes will be conducted in a new $1 million research center built by Picker X-Ray Corp. Research will include determining the effects of radiation on materials, developing new radiographic testing techniques, and studying chemical composition and crystal structure of materials.

▸ A new laboratory designed to perform physical and chemical studies of precious metals and fused quartz has been put into operation by the Research and Development Div., Engelhard Industries, Inc.

Specific studies include: improvement of high temperature properties of the platinum metals; measurement of basic properties such as thermal expansion, Young's modulus and specific heat; and development of new alloys.



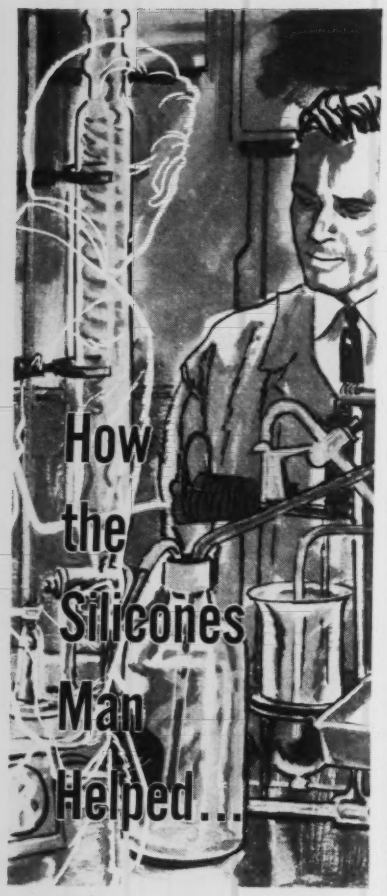
"Look, take your ductile-brittle transformation temperature and . . . "

41st Metal Exposition To Be Held Nov 2-6

"Materials and Fabrication Preview of the Soaring Sixties" is the theme around which the American Society for Metals has planned its 41st National Metal Exposition and Congress.

The exposition, set for Nov 2-6 at Chicago's International Amphitheatre, will present a "forecast of materials, products and processes." According to Chester L. Wells, exposition manager, displays will include latest cost saving equipment, newly developed metals and alloys, and advanced metalworking techniques.

Sessions at the technical conference will cover titanium, steels, high strength steels, creep and deformation, physical metallurgy, mechanical working, nuclear metals, austenitic alloys, and other areas. At least two special events have been scheduled: 1) a symposium on rare earths, and



GREATER HEAT AND WEATHER STABILITY FOR COLD-BLENDED METALLIC PAINTS

Manufacturers of automotive components—manifolds mufflers, tailpipes—can lengthen the life of parts subject to wetting and oxidation with a silicone resin specially designed by UNION CARBIDE. Industrial stacks, ducts, vents, ovens, conveyors, and other equipment get longer-lasting protection. Many other producers and users of metal products will find benefits from metallic-pigmented paints made with the new silicone resin.

When used for cold-blending with alkyd, melamine, and acrylic resins, the new silicone product gives coatings greatly increased thermal stability and weather resistance. Blended with aluminum and other metallic pigments, the resin mixtures supply all the desirable high-temperature properties of straight silicones at a lower cost.

Paint formulators will find numerous other advantages by using this silicone resin. Its compatibility with organic systems is superior to resins traditionally employed. The inherent film toughness and adhesiveness of organics is retained—blends are easy to prepare, apply, and cure. Substantial savings in materials result, since only low concentrations of the resin are required.

The new UNION CARBIDE silicone product can also be cold-blended with organics to meet applicable military specifications.

EXTENDING THE USES OF SILICONE WATER REPELLENTS

Water repellents formulated with silicones are now standard in specifications for above-grade masonry by many engineers and architects. The silicone resin penetrates into pores and crevices, eliminating water seepage and checking efflorescence. A special type of silicone resin was developed for use on concrete highways, bridges, dams and airport runways, which is effective in minimizing the cracking and spalling caused by alternate freezing and thawing conditions.

Cooperative efforts of asbestos shingle manufacturers and the Silicones Man have resulted in another silicone water repellent that keeps asbestos shingles clean and colorful, despite the weather. The silicone resin, by lining tiny cracks and crevices in the asbestos composition, prevents entry of rain-borne dirt and other soiling particles. Foreign material that settles on the surfaces is rinsed away by the rain. Since the silicone is colorless and transparent, the shingles retain their original color and appearance.

CAR OWNERS (AND THEIR WIVES) WILL BE GLAD TO HEAR ABOUT THIS

Here's what the operators of a certain government transportation unit do to eliminate hard-to-find squeaks in their fleets of vehicles: They apply just a bit of silicone lubricant to the rubber weather stripping and fan belts. This not only cuts out squeaks for several months, it restores flexibility to the rubber. Despite the weather—rain, heat or cold—it won't turn sticky or messy . . . doesn't harm paint or metal.

The Silicones Man is accustomed to helping solve problems like these . . . and he may be able to help you, too. For background information on these and other applications, write Dept. IM-0904, Silicones Division, Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. In Canada: Toronto 7.

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News OF INDUSTRY

2) the second Woodside Memorial Panel covering composite materials, explosive forming, refractory metals and new fabricating techniques.

The complete technical program, registration information, and list of exhibitors, will appear in the next issue of M/DE.

ASA Approves New Plastics Standards

Fifteen plastics standards published by the American Society for Testing Materials have been approved as American standards by the American Standards Assn. (ASA).

The standards, which include four specifications, ten test methods and one measuring method, were originally developed during the 1940's. According to ASA, most of the standards were revised during the 1950's and have now achieved national recognition and broad general acceptance.

The standards include: *specifications* for ethyl cellulose molding compounds, cellulose acetate sheet, cellulose nitrate sheet, and molds for test specimens of molding materials; *test methods* for stiffness properties of nonrigid plastics, Rockwell hardness, deformation, haze and luminous transmittance of transparent plastics, luminous reflectance, transmittance and color, specific gravity, acetone extraction of phenolic molded or laminated products, apparent density and bulk factor of granular thermoplastic molding powder; and a *measuring method* for shrinkage of molded plastics.

Copies of the newly approved standards are available at 30¢ each from ASA, 70 E. 45th St., Dept. PR 73, New York 17.

Lead-Zinc Research Gains Momentum

The joint American Zinc Institute-Lead Industries Assn. (AZILIA) Expanded Research Program, which was recently created to promote the use of zinc and lead, is now actively engaged in a number of re-

AT LAST A CONCLUSIVE NON-DESTRUCTIVE TEST OF PRESSURE TUBING QUALITY

MEETS A.S.T.M. SPECIFICATIONS—Damascope is a new and improved method of RADAC eddy current testing. It consistently reveals surface and sub-surface cracks, seams, splits, holes, inclusions and other discontinuities not revealed by any other inspection method. On production run testing, Damascope's range of sensitivity exceeds requirements for pressure tubing outlined in A.S.T.M. Book of Standards, Part I.

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Write for bulletin describing operation, range of sensitivity, advantages, and general background on Damascope testing.

EVERY TUBE IS TESTED—All Damascus pressure tubing is now Damascope inspected in addition to other accepted testing procedures. Damascope is an absolute test of quality, revealing the presence, location and size of harmful flaws. The entire periphery of the tube is examined inside and out, through the wall, and for the full tube length. *This is a 100% check*—each tube is inspected and imperfect tubes are automatically rejected.

SUITABLE FOR NUCLEAR WORK—For nuclear or other critical applications, Damascope can be even more closely calibrated to yield a tube of super quality. Damascope is powered by batteries which eliminate the variable effects caused by current surges. It also employs modulation analysis to separate eddy current signals from background interference.

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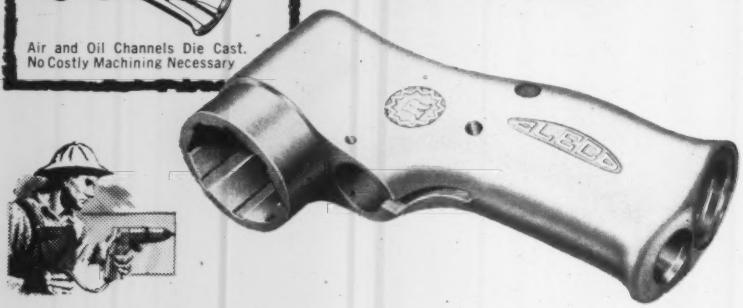
DIE CASTINGS KEEP COSTS WAY DOWN



Producing the air drill handle (above) for the Cleco Air Tools Division of the Reed Roller Bit Company could have meant complicated, costly and extensive machining procedures. *But* Production Die Casting was called in and the handles were produced to exact specifications, saving time and machining costs for Cleco.

Die casting maintains the closest tolerances and allows maximum design flexibility. Quality is extremely high. High tensile strength zinc alloy (45,000 psi) and 360 Aluminum (40 to 43,000 psi) insure dense, durable castings. Call or write Production Die Casting Company, the South's leading die caster, to learn how you can keep production costs down without sacrificing quality.

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News OF INDUSTRY

search projects.

According to Dr. Schrade F. Radtke, director, the following are some of the projects currently underway: improved electroplated coatings for zinc die castings used by the automotive and appliance industries; zinc oxide paint formulations for exterior dwellings; new galvanizing alloys for hot water tanks in critical U.S. locations; methods of extending service life of zinc lithograh printing plates; cathodic protection of tankers with zinc anodes; coatings to minimize "wet storage strain"; zinc battery cans; and comparative corrosion evaluation tests of various forms of zinc-protected steel sheet, rolled zinc and aluminized steel in various atmospheres.

According to Dr. Radtke, the program will be devoted to the following three general areas; 1) improvement of products by minimizing limitations and enhancing inherent advantages; 2) development of new products, new applications and new markets; and 3) fundamental research aimed at seeking new knowledge about zinc and lead that will enlarge the scope of both metals.

Plastics Film Catalog

The latest edition of the Film Catalog of the Plastics Industry is now available from the Society of the Plastics Industry, Inc.

The catalog lists available films on practically every phase of the plastics industry: raw materials, manufacturing techniques, converting processes, fabrication, molding, applications, etc. A brief description of each film, its sponsor and how to obtain it is also included.

Re-Entry Structures Subject of Symposium

A symposium on "Processing of Materials for Re-Entry Structures" will be held next March in Dayton, Ohio. It will be sponsored by the Midwest Society of Aircraft Materials and Process Engineers (SAMPE).

Officers of this SAMPE group recently elected are: president—Joseph

A REVIEW OF PHOSPHATE COATINGS

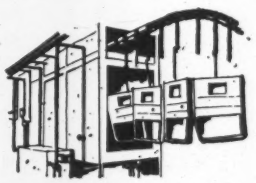
Specified for the Protection of Metal Surfaces

By HUGH GEHMAN, Assistant Manager, Product Development Dept., AMCHEM PRODUCTS, INC.

Phosphate coatings are protective inorganic finishes that actually change the chemical nature of metal surfaces. The metal reacts with the applied phosphate solution to form a nonmetallic, crystalline coating which serves to:

- **Improve paint adhesion**
- **Provide protection against corrosion**
- **Increase lubricity of friction surfaces**
- **Facilitate mechanical deformation of metals**
- **Decorate—in many instances**

Satisfactory protection of steel, zinc and aluminum surfaces against corrosion, paint peeling and blistering,



Typical automotive spray installation.

and hard wear requires precision methods of chemical conversion coating.

Types of Conversion Coatings

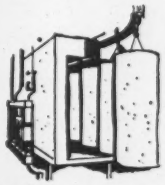
There are seven classes of chemical conversion coatings commonly specified and used throughout industry today. They are as follows:

Zinc-iron phosphate (Amchem Granodine). This is the heaviest type of coating (gray in color) used for prepaint treatments on steel, iron and zinc surfaces. The process requires five or six operations: cleaning; rinsing; rust removal, if necessary; coating; rinsing; and a second rinse. Coating weight ranges from 100 to 600 mg per sq. ft.

Medium or large volume production of automobile bodies, appliances, projectiles and cabinets can be handled effectively.

The coating solution improves paint adhesion by forming a crystalline deposit over the metal surface. This deposit is rough, as revealed microscopically, and so offers an ideal gripping surface for paint particles.

Manganese-iron phosphate (Amchem Thermoil-Granodine). This is a heavy black coating used on friction surfaces to prevent galling, scoring and seizing of parts. Typical metal parts treated are pistons, piston rings, gears, cylinder liners, camshafts, tappets and various small arms components.



Typical appliance treatment line.

Iron phosphate (Amchem Duridine). This is a comparatively new process that places a light coating on surfaces for improved paint adhesion. Since cleaning and coating occur in the same bath, it has only three to five stages.

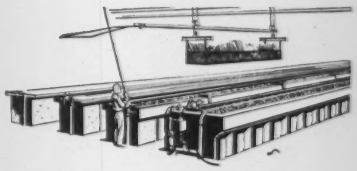
The iron phosphate treatment is a spray process suited for medium to large volume, large or small work. Precleaning is normally unnecessary, an economy factor in its favor.

Products protected by this process are steel or iron fabricated units, such as cabinets, washing machines and refrigerators. Weight of coating is 50 to 100 mg per sq. ft.

Zinc phosphate (Amchem Lithoform). This is a crystalline coating produced on galvanized iron and other zinc surfaces—also cadmium—for improving paint adhesion. The purpose of the coating is to provide a paint-gripping surface and to prevent the reaction between acidic components of the paint and the zinc metal, with the formation of soaps and loss of paint adhesion.

This coating is applied in weights of 75 to 500 mg per sq. ft. There are no limitations on volume or production or on size of products treated. Zinc phosphate coating is used on zinc alloy die castings, zinc or cadmium plated sheet or components, hot dip galvanized stock, and Galvanneal.

Amorphous phosphate (Amchem Alodine). This a protective coating for aluminum and aluminum alloys.

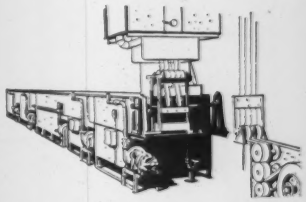


Typical aircraft dip installation.

It may be used in place of anodic deposition for improved paint adhesion and corrosion resistance.

This coating is practical for production in any volume. Coating weight is 100 to 600 mg per sq. ft. Products treated include aluminum awnings, doors and windows, aircraft and aircraft parts, missile parts, roofing and siding. Particularly good when aluminum is painted prior to forming.

Zinc-iron phosphate for oil absorption (Amchem Permadine). This is a relatively heavy coating adapted to the retention of rust-inhibiting drying or nondrying oils and waxes on ferrous metal surfaces. The coating is applied to a weight of 1000 to 4000 mg per sq. ft.



Typical continuous strip line installation.

The process is satisfactory for large or small work in any volume—nuts, bolts, hardware, guns, tools, etc.

Zinc-iron phosphate for metal forming (Amchem Granodraw). This is a specialized coating used in conjunction with a suitable lubricant to facilitate the cold mechanical deformation of steel. The coating acts as an anchor for the lubricant throughout drawing, extrusion, and cold forming operations.

It is a successful treatment for products such as blanks and shells for cold forming, heavy stampings, impact extruded shapes, drawn wire and tube.

For more complete information about any one or all of these chemical conversion coatings, contact an Amchem sales representative or write us at Ambler 17, Pa.

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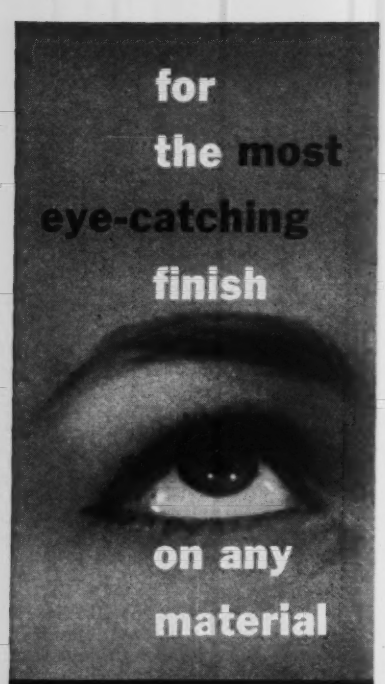

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If you are a coating user, you will want to learn more about how a unique Nacromer coating will help your sales. To obtain additional information, mail the coupon below. Do it today.

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News OF INDUSTRY

Bayer, Aeronca Mfg. Corp.; vice president—F. J. Martin, WADC; secretary—F. E. Robinson, General Electric Co.; and treasurer—T. M. Allen, Armco Steel Corp.

Plastics Engineers Set Technical Meeting

A national technical conference on "Plastics Engineering—State of the Art Today" has been scheduled by the Southern California Section of the Society of Plastics Engineers, Oct 13-14 at the Ambassador Hotel, Los Angeles.

Experts from all over the country will present papers on properties and processing of polypropylene, new alkyd molding compounds, polyurethane foam, quality control, equipment and techniques for the extrusion of thermoplastic materials, evaluation of plastics piping systems, and new developments in adhesives and sealers.

Engineers

Al Hunter has been appointed manager of engineering, Beardsley & Piper, a division of Pettibone Mulliken Corp.

Dr. F. C. Langenberg has been named manager of process research, Crucible Steel Co. of America.

Dr. Stephen A. Leone, Eugene D. Robie, and **David W. Rudd** have joined Metal Hydrides Inc.'s Research and Development Laboratory staff.

John G. Ziemann has been appointed assistant chief metallurgist, Metals Div., Kelsey-Hayes Co.

Dr. Herbert M. Hershenson has been named assistant technical director, product planning, Baird-Atomic, Inc.

Monroe Seligman, Tenney Engineering, Inc., has been elected a director of Environmental Equipment Institute.

Robert B. Shulters has been named director of engineering at Thor Power Tool Co.'s Aurora, Ill. Works.

Dr. William C. Knopf has been appointed technical director, Technical Center, U. S. Industries, Inc.

L. B. Stearns has been appointed to the newly created position of project manager, **Don C. Atkins** has been named director of the new Technical Dept., and **J. T. Willoughby** has been

GRAPHITE AIDS METALLURGY

Standard and custom grades of Graphite Specialties graphite are being employed as molds, dies, crucibles and piping in the production of titanium as well as for chlorinating a wide range of metals. Formulations with individualized properties are available, or "GRAPH-I-TITE" can be furnished.

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Most types of Graphite Specialties graphite can be furnished in rod, tube, or can be molded or extruded in special shapes, or can be machined to close tolerance.

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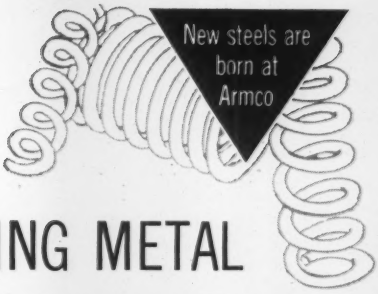
For more information, circle No. 443



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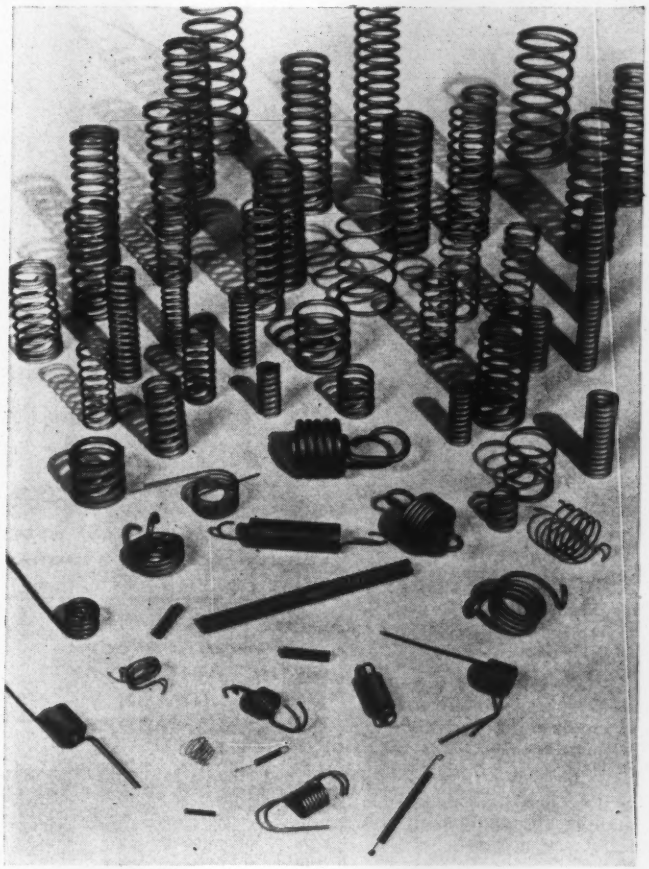

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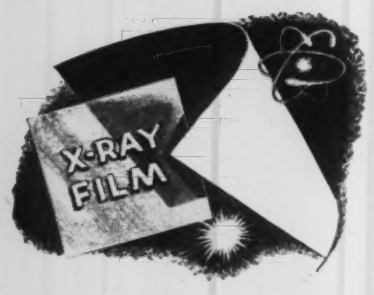

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News OF INDUSTRY

named chief engineer, U. S. Chemical Milling Corp.

John Alico is now director of engineering, Walworth Co.

Dr. Peter D. Shroff has been named to the newly created position of manager, product engineering, Narmco Resins & Coatings Co.

Raymond C. Allen has been appointed manager of engineering, Instrument Dept., General Electric Co.

George Russell is the new chief engineer, Amchem Products, Inc.

Louis R. Wanner has been appointed to the newly created post of chief engineer, Parts Div., Sylvania Electric Products Inc.

Harold C. Hanson is now assistant chief engineer, Magnetic Controls Co.

Harold A. Mosher, Eastman Kodak Co., has been elected president, National Society of Professional Engineers.

John C. Redmond has been appointed director of research, Firth-Sterling, Inc.

Kenneth A. Erwin has been named administrative manager, Research and Development Dept., Marbon Chemical Div., Borg-Warner Corp.

Fred W. Drosten has been named director of metallurgical development, Heavy Minerals Co., a subsidiary of Vitro Corp. of America.

Hugo C. Johnson, Jr., has been appointed assistant director, Product Development Div., Commercial Dept., U. S. Steel Corp.

Herbert S. Lindahl and **Gordon Kayser** have been named chief product engineers, Betz Div., Bohn Aluminum & Brass Corp.

Joseph J. Jacobs has been named assistant chief engineer, West Allis Pump Dept., General Products Div., Allis-Chalmers Mfg. Co.

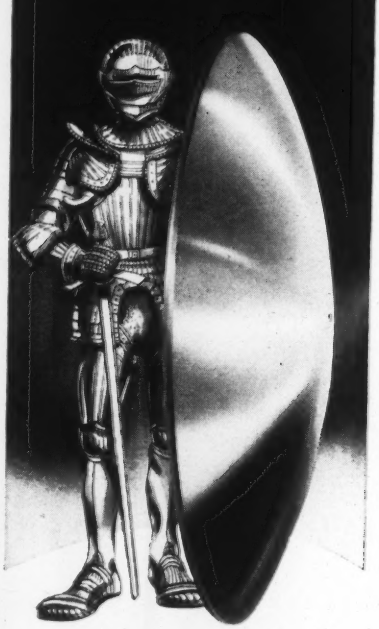
E. T. Walton has been appointed director of metallurgy, Crucible Steel Co. of America.

David E. McElroy has been appointed manager of International Resistance Co.'s newly formed Plastic Products Div.

Lee Turhune has been named assistant development manager, Resinite Dept., Borden Chemical Co.

Dr. Karl W. Maier has been named scientific advisor to the vice president

SHIELD FOR THE BATTLE OF SURVIVAL IN SPACE



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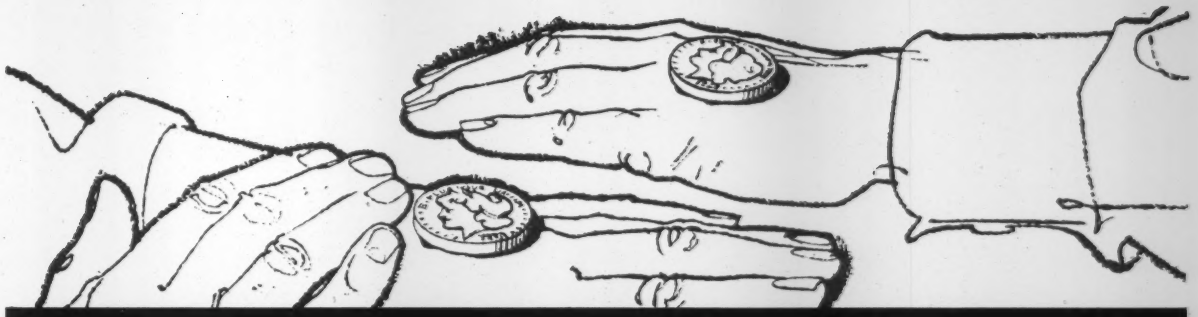

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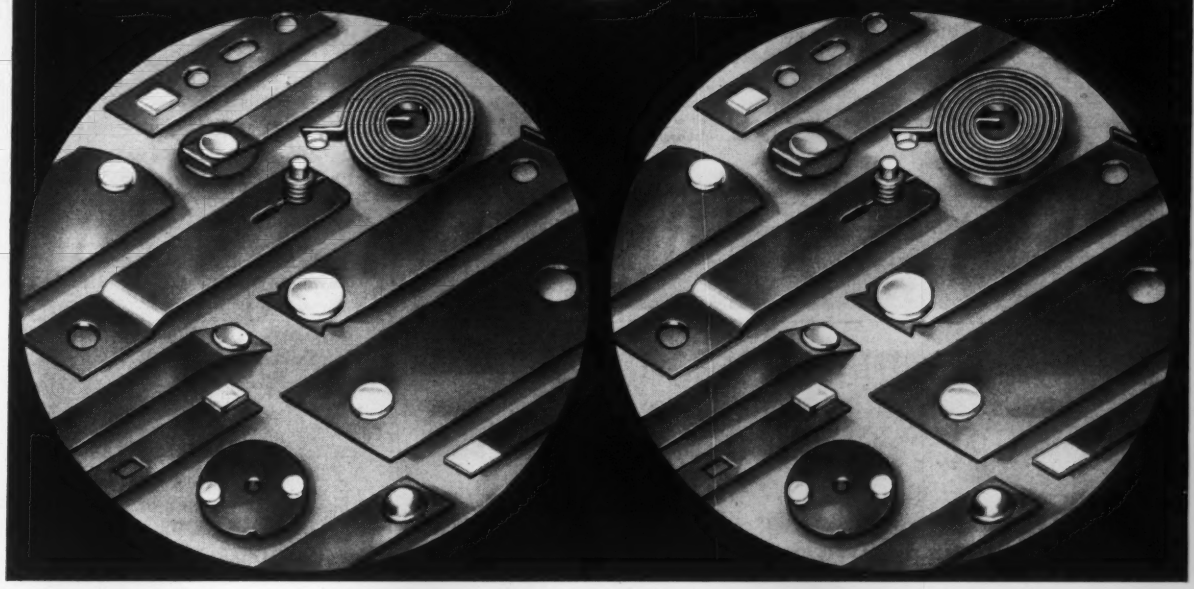

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News OF INDUSTRY

for research and development, Winchester-Western Div., Olin Mathieson Chemical Corp.

George F. Paulus is now product development chemist, Acheson Colloids Co.

Ade Czarnecki has been named chief engineer, Anchor Steel & Conveyor Co.

Companies

Chemical Milling International Corp. is a new company formed by Frank L. Bailey and E. Lawrence Brevik. The company is located at 1330 E. Franklin Ave., El Segundo, Calif.

Sun Oil Co. and **Olin Mathieson Chemical Corp.** have joined forces for the construction of an $8 million urea plant in North Claymont, Del.

Turbocraft, Inc., is the new name for **Turbocraft Co.,** 492 E. Union St., Pasadena, Calif.

Zero Mfg. Co., Burbank, Calif., has purchased **Electronic Welding Co.**

Union Carbide Plastic Co., a division of Union Carbide Corp., has begun production at its new liquid epoxy resins plant at Marietta, Ohio.

W. R. Grace & Co. has acquired the business and assets of **Hatco Chemical Co.**

Philco Corp. has broken ground for a new Transac computer center near Willow Grove, Pa.

Dobeckmun Co., a division of Dow Chemical Co., has expanded its Research, Product Development and Technical Service Div., and has named **George Lacy** director of research and preliminary development.

Miniature Precision Bearings, Inc., is constructing a $500,000 research center at Keene, N. H.

Tomkins-Johnson Co. has moved to new manufacturing and office facilities at 2425 W. Michigan Ave., Jackson, Mich.

Warminister Fiberglass Co. is a new company formed by Fischer & Porter Co. for the production of fiberglass-reinforced plastic parts. Warminister is located in Hatboro, Pa.

Singer Mfg. Co. has formed a Special Products Div. with H. Neal Karr as its head.

Filon Plastics Corp. has broken ground in Hawthorne, Calif., for a

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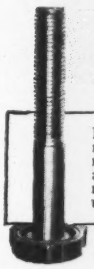

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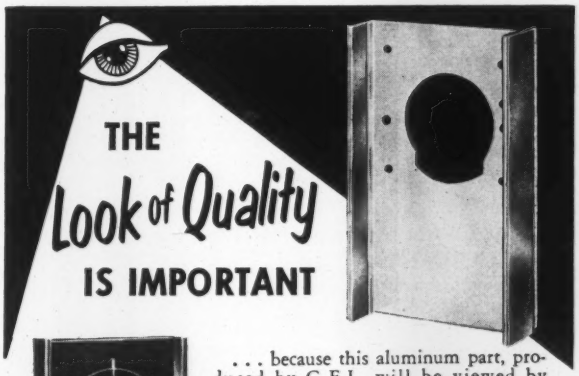

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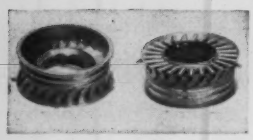
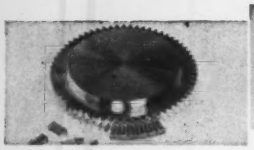

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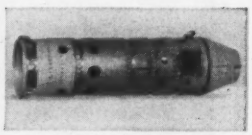
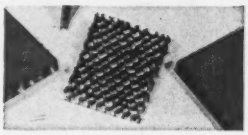

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News OF INDUSTRY

new $1 million plant for the production of fiberglass-reinforced plastics building panels.

Pittsburgh Steel Co. has completed an eight-year, $111-million expansion and improvement program with the construction of a billet mill at its Monessen, Pa., works.

Fairchild Camera and Instrument Corp.'s Industrial Products Div. has moved to larger quarters at 580 Midland Ave., Yonkers, N. Y.

E. I. du Pont de Nemours & Co., Inc., has formed a new Industrial and Biochemicals Dept. which will encompass all operations of the Grasselli Chemicals Dept., together with operations of the Polychemicals Dept.

Chemstrand Corp. plans to construct a multi-million-dollar research laboratory in Research Triangle Park, N. C.

Applied Electronics Corp. of New Jersey has moved to new facilities at 22 Center St., Metuchen, N. J.

U. S. Chemical Milling Corp. has acquired **Darco Industries, Inc.,** which has plants in El Segundo and Glendale, Calif.

Narda Microwave Corp. has formed a new High Power Electronics Div.

Electric Steel Foundry Co. has purchased **Pacific Alloy Engineering Corp.,** which will become a subsidiary of ESCO under the name of Pacific Alloy Corp.

Marlin Rockwell Corp. plans to build a million-dollar extension to its manufacturing facilities at Plainville, Conn.

Metlspin, Inc., a new metal spinning firm, has begun production at its facilities in Fort Atkinson, Wis.

Albany Products Co., Inc., has acquired **B & M Stainless Fasteners Inc.**

Pacific Moulded Products Co., Los Angeles, has purchased all outstanding stock of **W. B. Elfstrom Co., Inc.**

Schmidt Aluminum Casting Corp. has moved to a new factory at 2880 46th Ave. N., St. Petersburg, Fla.

A. E. Staley Mfg. Co. has acquired **U B S Chemical Corp.**

Monsanto Chemical Co. has expanded its Inorganic Chemicals Div.'s silica production facilities in Everett, Mass.

Michigan Chemical Corp. has begun production in its new magnesium oxide plant at Port St. Joe, Fla.

(News of Societies on p 228)

For more information, turn to Reader Service card, circle No. 404

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			Rm. 70°	Rm. 110°	L	W	H	L	W	H
Sub-Zero	SZH153	1.5	–95° F.	–85° F.	42″	28″	42¾″	23″	9″	12½″
Sub-Zero	SZH653	6.5	–85° F.	–75° F.	60″	28″	42¾″	47″	15″	16″
Sub-Zero	SZHC657	6.5	–140° F.	–125° F.	60″	28″	42¾″	47″	15″	16″
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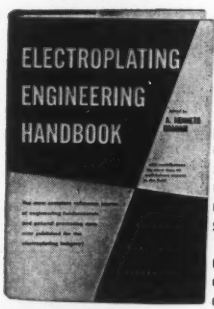

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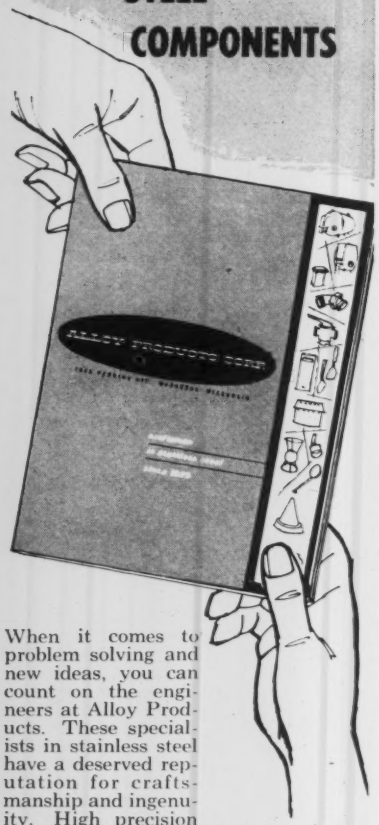

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News OF INDUSTRY

Societies

Metal Powder Industries Federation has moved to new quarters at 60 E. 42nd St., New York 17, N. Y.

Magnesium Assn. announces the following officers: president—Otis Grant, Magnode Products, Inc.; vice presidents—Charles Howe, Hills-McCanna Co., and John Thomson, Dominion Magnesium Ltd.; treasurer—Norman Gzowski, Garfield Alloys, Inc.; and secretary—Jerry Singleton.

American Society for Testing Materials has elected the following officers: president—F. L. LaQue, International Nickel Co.; vice president—Miles N. Clair, Thompson & Lichtner Co.; and senior vice president—A. Allan Bates, Portland Cement Assn.

At the Society's 62nd annual meeting the following honors were awarded: The Marburg Lecture, "New Polymers — New Problems," was presented by Herman F. Mark, Polytechnic Institute of Brooklyn. The Gillett Memorial Lecture, "The Role of Dislocations in Plastic Deformation (of Metals)," was presented by John C. Fisher, General Electric Co. Sam Tour Award—John B. Rittenhouse, California Institute of Technology; Richard L. Templin Award—J. H. Westbrook, General Electric Co.; and Charles B. Dudley medal—Robert J. MacDonald, Clevite Research Center, R. L. Carlson, Battelle Memorial Institute, and W. T. Lankford, U. S. Steel Corp.

American Society for Engineering Education announces the following 1959-60 officers: president-elect—Dr. Benjamin R. Teare, Jr., Carnegie Institute of Technology; vice presidents—Dr. Ralph G. Owens, Illinois Institute of Technology, and Dr. Howard W. Barlow, Washington State University; secretary — W. Leighton Collins, University of Illinois; and treasurer—Wendel W. Burton, Minnesota Mining & Mfg. Co.

Malleable Founders' Society has announced the following winners in its 1959 Redesign and Conversion Contest: First prize—P. C. Potter and C. D. Evans, Central Foundry Div., General Motors Corp. Other winners: Joe W. Beckham, Texas Foundries, Inc.; Joe W. Beckham and Neal Naranjo, Texas Foundries, Inc.; John L. Bill, Lehigh Foundries Co.; John H. Benko, Jr., Peoria Malleable Castings Co.; and Dale E. Holmes, Albion Malleable Iron Co.

(News of Meetings on p 230)

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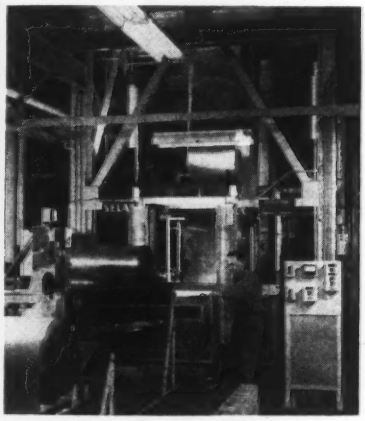

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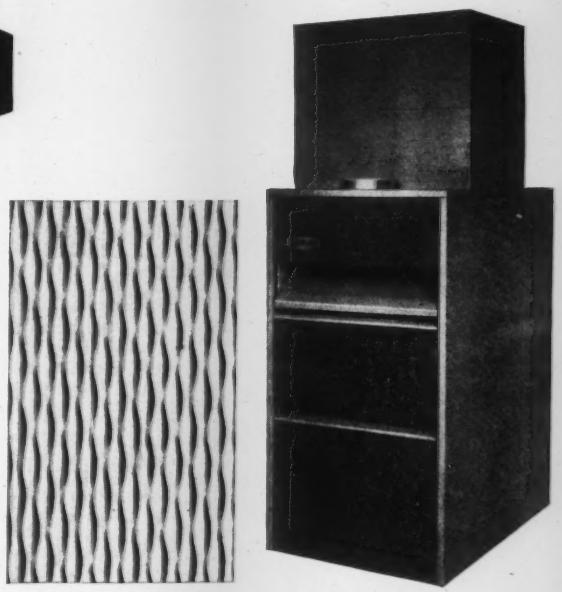

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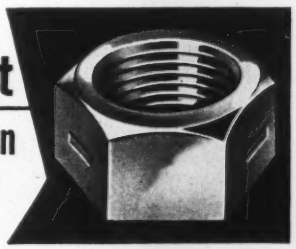

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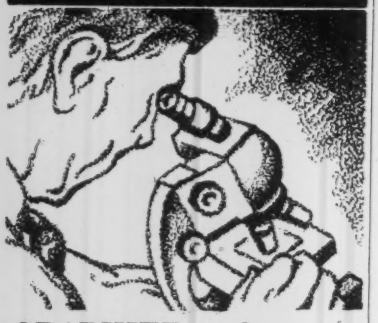

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News OF INDUSTRY

Meetings

APPLIED MECHANICS DIV., American Society of Mechanical Engineers; and American Society of Civil Engineers, 1959 West Coast conference of applied mechanics. Stanford, Calif. Sept 9-11.

SOCIETY OF THE PLASTICS INDUSTRY, INC., Midwest Section conference. French Lick, Ind. Sept 10-11.

AMERICAN CHEMICAL SOCIETY, 136th *national meeting. Atlantic City. Sept* 13-18.

AMERICAN DIE CASTING INSTITUTE and Die Casting Research Foundation, annual meeting. Chicago. Sept 16-17.

MALLEABLE FOUNDERS SOCIETY, industry meeting. Cleveland. Sept 18.

STEEL FOUNDERS' SOCIETY OF AMERICA, 57th fall meeting. Hot Springs, Va. Sept 21-22.

POWDER METALLURGY PARTS MFRS. ASSN., annual meeting. Detroit. Oct. 6-7.

INSTRUMENT SOCIETY OF AMERICA, 14th conference and exhibit. Chicago. Sept 21-25.

PORCELAIN ENAMEL INSTITUTE, annual meeting. White Sulphur Springs, W. Va. Sept 24-26.

AMERICAN WELDING SOCIETY, fall meeting. Detroit. Sept. 28-Oct 1.

SOCIETY OF THE PLASTICS INDUSTRY, INC., 15th New England Section conference. Portsmouth, N. H. Oct 1-2.

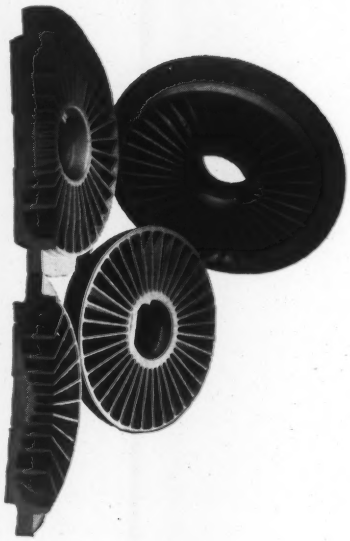
AMERICAN VACUUM SOCIETY, 6th national symposium on vacuum technology. Philadelphia. Oct 7-9.

GRAY IRON FOUNDERS' SOCIETY, INC., 31st annual meeting. San Francisco. Oct 7-9.

AMERICAN SOCIETY FOR TESTING MATERIALS, 3rd Pacific Area national meeting. San Francisco. Oct 11-16.

"TREATMENTS AND FINISHES FOR AEROSPACE MATERIALS" Conference, American Electroplaters' Society and Southwest Society of Aircraft Materials and Process Engineers. Fort Worth, Tex. Dec 8-9.

WATCH FOR 'SELECTOR'—The third edition of M/DE's *Materials Selector* —revised, expanded and updated— will be published in mid-October, following the regular October issue. The special issue is included in the M/DE subscription.



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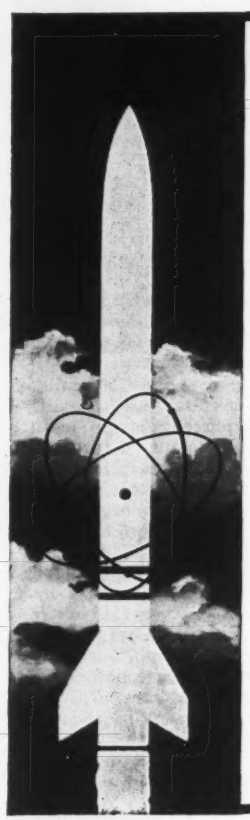

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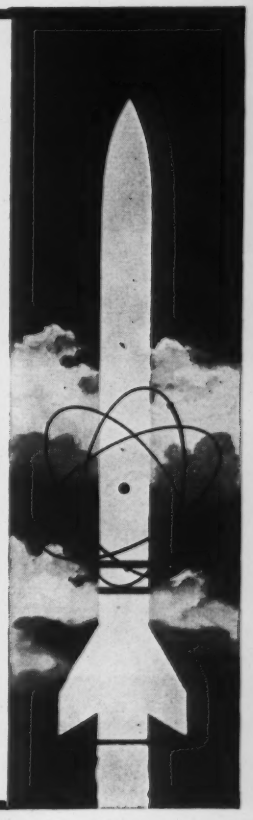

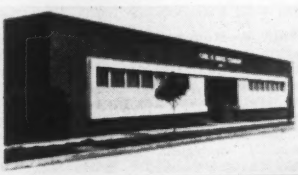

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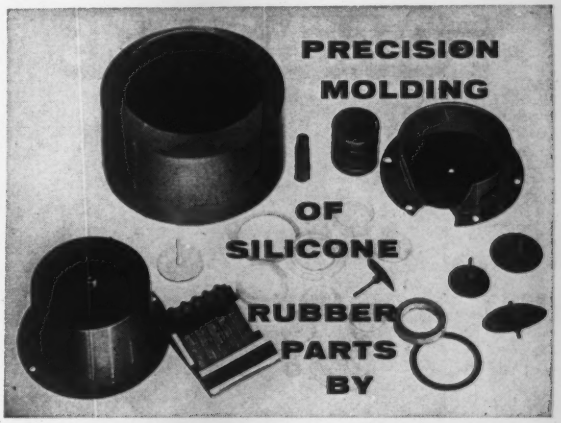

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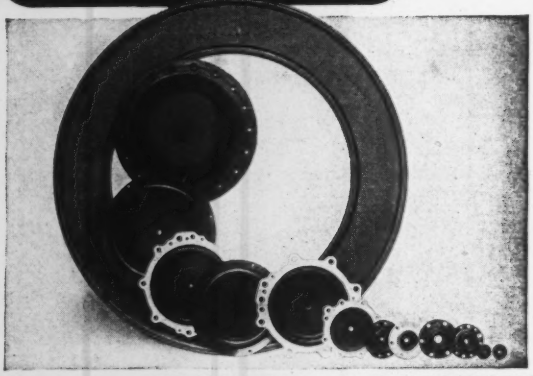

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TECHNICAL LITERATURE

(cont'd from p 46)

Books

Hot Organic Coatings. *R. B. Seymour. Reinhold Publishing Corp., New York. 1959. Cloth, 6 by 9 in., 233 pp. Price $7.50*

Of the more than 500 million gallons of coatings used annually, only a small percentage are hot-applied. This book should go far in stimulating keener interest in hot organic coatings and convince even the most critical that hot organic coatings have a definite place in the coatings art.

The book contains chapters on widely used hot organic materials such as asphalt, coal tar pitch, petroleum waxes and cellulose derivatives. Specific information on formulations of proprietary products is included. Additional chapters deal with hot melt applications without solvent such as peel coatings, protective linings, flame spraying and the fluidized bed process.

ASTM Standards, 1958. *American Society for Testing Materials, Philadelphia, 1958. Cloth, 6 by 9 in.*

Part 5—Masonry Products, Ceramics, Thermal Insulation, Acoustical Materials, Sandwich and Building Constructions, Fire Tests. *1176 pp. Price $12*

Included are standards for porcelain enamel, glass and glass products, refractories, thermal insulation, sandwich constructions, and acoustical material. Also, standards for brick, asbestos-cement products, natural building stones, concrete masonry units, structural tile, tests of building constructions, and fire tests.

Part 6—Wood, Paper, Adhesives, Shipping Containers, Cellulose, Leather. *1152 pp. Price $10*

Included are standards for wood, paper and paper products, adhesives, leather, cellulose and cellulose derivatives, and shipping containers.

Part 8—Paint, Naval Stores, Aromatic Hydrocarbons, Coal and Coke, Gaseous Fuels, Engine Antifreezes. *1424 pp. Price $12*

Standards for shellac, varnish and varnish materials, resins and resin solutions, lacquer and lacquer materials, paint tests, paint weathering tests, traffic paints, pigments, oils and thinners, drying oils and driers. Also covered: bituminous emulsions, aromatic hydrocarbons, gaseous fuels, putty, antifreezes, naval stores, coal, coke and printing ink.

Solid State Magnetic and Dielectric Devices. *Edited by Harold W. Katz. John Wiley & Sons, Inc., New York. 1959. Cloth, 6 by 9 in., 542 pp. Price $13.50*

The 11 chapters discuss electrostatic and magnetostatic field theory; origin of magnetic and dielectric properties; electrostrictive and magnetostrictive systems; nonlinear magnetic and dielectric materials; electromechanical applications; small signal applications; ferrites at microwave frequencies; magnetic and dielectric amplifiers; digital techniques employing square loop materials; magnetic recording; and magnetic and di-

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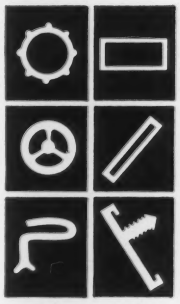

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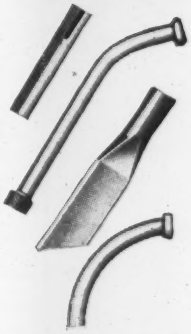

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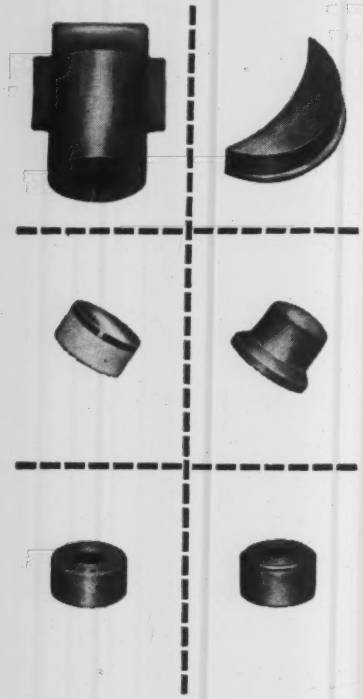

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TECHNICAL LITERATURE

electric measurements. Four appendices discuss reciprocity in linear systems; tensor dielectric constant of a plasma; magnetoresistance; and parametric devices. The book, written by authorities in the field, is well illustrated with tables and diagrams.

Magnesium Looks Ahead: Proceedings 14th Annual Convention. *Magnesium Assn., New York. 1959. Paper, 7 by 9 in., 200 pp. Price $5.50*

Papers included in this book are: magnesium in automotive wheels; magnesium in automotive equipment; mass production of drawn magnesium parts from coil stock; automotive use of magnesium mill products for tooling; use of magnesium to reduce vibration in machinery; vibration damping capacity of magnesium alloys; a high damping magnesium alloy for missile applications; experience with HM21 magnesium alloy in ramjet manufacture; optimum fabricating methods for a magnesium component; use of magnesium castings in military photographic equipment; the magnesium industry in England; and plating finishes for magnesium.

Reports

Thermal properties of glass MEASUREMENT OF SOME THERMAL PROPERTIES OF THREE GLASSES. *J. V. Melonas, P. C. Covington and C. D. Pears, Southern Research Institute. Aug '58. 20 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price 50¢ (PB 151419)*

Describes the measurement of thermal conductivity and specific heat of soda lime silica plate glass, borosilicate glass and alumina silicate glass. Temperatures for thermal conductivity tests ranged from 100 F to the strain point of the material, whereas temperatures for specific heat tests ranged from —100 F to the strain point.

Lead monoxide coatings LUBRICATING PROPERTIES OF LEAD-MONOXIDE-BASE COATINGS OF VARIOUS COMPOSITIONS AT TEMPERATURES TO 1250 F. *H. E. Sliney, Lewis Research Center. Feb '59. 22 pp. Available from National Aeronautics and Space Administration, Washington, D. C. (No. 3-2-59E)*

Study of ceramic coatings containing lead monoxide as dry film lubricants. Several of the coatings protected metals against adhesive wear at temperatures from 75 to 1250 F.

Oxides for capacitors ULTRATHERMIC CAPACITORS. *G. W. Monk, American Machine & Foundry Co. Aug '58. 81 pp. Available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C. Price $2.25 (PB 151256)*

Study shows that magnesium and aluminum oxides have insulation resistance high enough for use in capacitors operating at 900 F under nuclear radiation. Boron nitride is useful in the absence of radiation. The best methods for fabricating magnesium and aluminum oxides are a slurry dipping technique, fusing of magnesium oxide to platinum electrodes, electrolytic deposition of the oxides, and assembly of cold pressed disks and electrodes.

Grinding titanium sheet BELT GRINDING OF TITANIUM SHEET AND PLATE. *Mar '59. 10 pp. Defense Metals Information Center, Battelle Memorial Institute, Columbus 1, Ohio. (No. 11)*

Information on belts, contact wheels, speeds, feeds and fluids used.

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Compression deflection *(compressed to 75% of original thickness)*	
Room temperature	
Type firm	12-18 psi range[1]
Type medium	8-14 psi range[1]
—65°F. pct. difference	—10% to +15%[1]
212°F. pct. difference	+ 5% to +10%[1]
Compression set *(compressed to 50% of original thickness)*	
22 hrs. @ 70°F.	0-5% (firm)[1] 5-30% (medium)[1]
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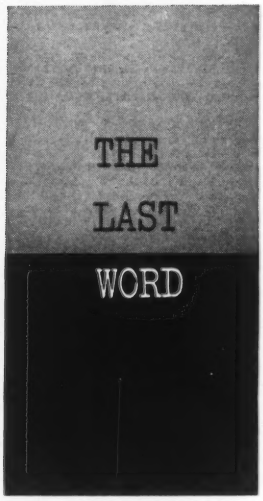

by ***H. R. Clauser***
Editor

Recently an engineer who was urgently in need of accurate data on the specific heat of type 347 stainless steel in the temperature range from –148 to 1112 F, made one telephone call and received most of the required information. That one telephone call eliminated the need for a six weeks' "crash" program in his laboratory, and saved his company $30,000.

It's not easy to find data you want

Unfortunately, not all such incidents have this happy ending. In fact, this case is probably more the exception than the rule. Too frequently the search for specific and precise property information on a material under a given set of conditions ends in failure. And many times the search fails, not because the data does not exist, but because it cannot be found.

Today the mass of property data is so great, so widely scattered and so unorganized, that much of it remains either unknown or is unavailable to materials users when it is needed. Likewise, materials research projects are so numerous and the results are so poorly disseminated that a large share of our research effort is either wasted or not fully used. Also, a search often reveals wide differences in property data from various sources, and the engineer has no way of knowing which data is the most accurate. And finally, despite the wealth of basic property information, there are still many important gaps in the data. Usually these gaps are only discovered when the data is urgently needed.

What is being done now

There are some serious attempts under way to solve this problem of collecting and disseminating specific property data. One small attempt, with which we are directly associated, is the M/DE reference issue, the *Materials Selector.* It contains about 25,000 entries of property data on the most important engineering materials and is proving extremely helpful to engineers and designers.

Perhaps the largest and most ambitious program is that of the National Research Council. It has recently organized an Office of Critical Tables, whose job it will be to replace the present tables which are now nearly 30 years old. The goal is to compile on a continuing basis the basic properties of all materials.

A most significant program is that of the Thermophysical Properties Research Center at Purdue University (M/DE, Jan '59, p 178). It was to this center that the successful phone call mentioned earlier was made. The goal of this institution is to be the world center for the systematic collection, analysis, correlation and dissemination of thermophysical properties information, and to provide facilities for research to fill in the gaps in this property area.

Let's set up property centers

It would seem that systematic programs operated on a continuing basis by "property centers" would be the most effective and economical way to meet the present and future needs for adequate data on all the properties on all materials. The Thermophysical Properties Center at Purdue might well serve as the prototype for similar centers of knowledge in all the other materials property areas.

The cost for such centers would be relatively small. For example, the center at Purdue estimates that about $30 million per year is spent throughout the world on thermophysical properties research and that only 1% of this amount is required to operate such a center. Surely we could well afford to allot 1% of our research funds to establishing and operating property centers that would preserve and make more readily available the results of our research investment.

extrusions

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B. U. Adamson, Goodrich-Gulf Sales Engineer (left) watches M. A. Bedics, Chief Engineer of Pawling Rubber Corporation, make hardness test on a stock that includes Micro-Black masterbatch.

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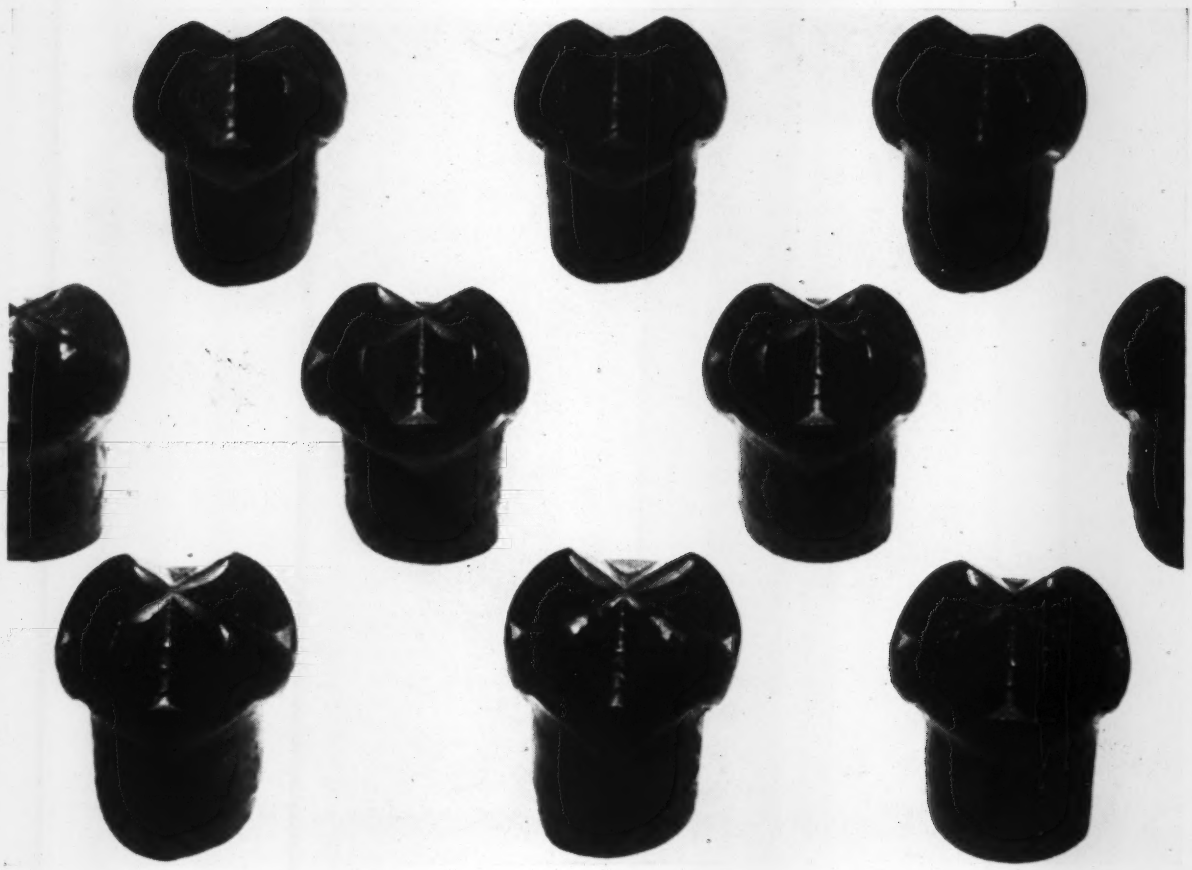

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